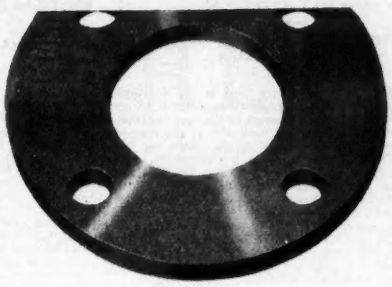

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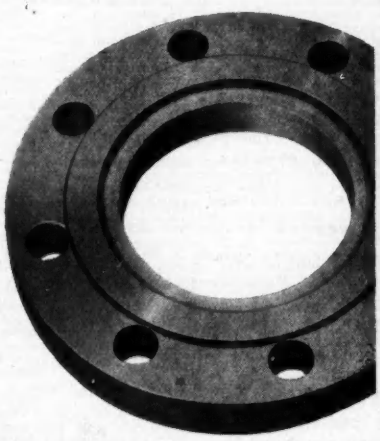

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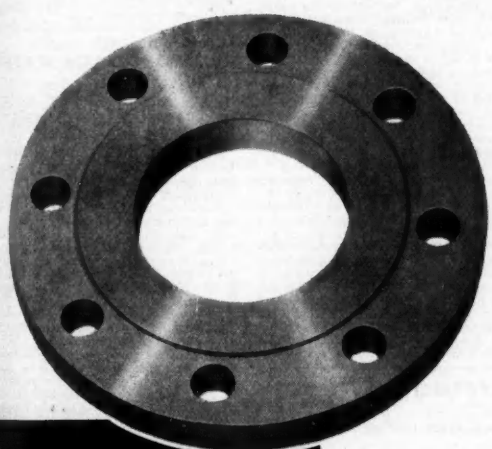

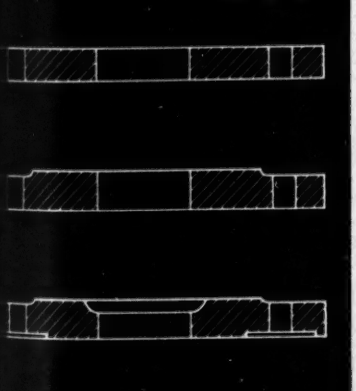

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

THE UNIVERSITY OF LEEDS

DEPARTMENT OF TEXTILE INDUSTRIES

RESEARCH FELLOWSHIP IN TEXTILE ENGINEERING

The Council invites applications for two RESEARCH FELLOWSHIPS IN TEXTILE ENGINEERING, each tenable for one year in the first instance, renewable, at a salary on the scale £500–£750, according to qualifications and experience, plus F.S.S.U. Candidates for one Fellowship should hold at least a Second-Class Honours Degree in Physics, Chemical or Mechanical Engineering, and the successful candidate will be engaged on problems involving the hydrodynamics of suspensions of fibres, filtration, and other related processes. For the other Fellowship, candidates should hold at least a Second-Class Honours Degree in Mechanical Engineering or in Physics, and the successful candidate will be engaged on fundamental studies connected with the weaving loom. For neither Fellowship is previous experience in textile technology necessary.—Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained), not later than 1st August, 1954. E9600

UNIVERSITY COLLEGE OF THE GOLD COAST

RESIDENT ELECTRICAL ENGINEER

Applications are invited for appointment as RESIDENT ELECTRICAL ENGINEER. The person appointed will be responsible for the running and maintenance of the College power station with an installed capacity of about 4000kW., and also of all related transmission, distribution and consumer's installations. Candidates must be Corporate Members of Institution of Electrical Engineers, London, or possess equivalent qualifications. They must have considerable experience in power station management.

Salary, according to qualifications and experience, will be fixed within the range £1650 to £1900. F.S.S.U. or equivalent gratuity. Appointment will be for five years initially; family allowance at the rate of £100 per child (maximum £300); free passages for appointee, wife and maximum of three children; outfit allowance of £60 on first appointment; annual leave in the United Kingdom.

Applications, six copies, naming three referees and stating age, full qualifications and year by year education and experience, to be sent before 9th August, 1954, to the Assistant Registrar (London), University College of the Gold Coast, 29, Tavistock Square, London, W.C.1. E9620

NOTTINGHAMSHIRE EDUCATION COMMITTEE

MANSFIELD TECHNICAL COLLEGE

Principal: R. F. BEATON, B.Sc. (Eng.), Wh.Sch.

ASSISTANTS, GRADES A AND B

Applications are invited for the following posts:—

AN ASSISTANT, GRADE B, IN ENGINEERING SUBJECTS

Candidates should be capable of teaching at least to the level of the Ordinary National Certificate and to Higher National Certificate in some subjects. Industrial or teaching experience in either mining mechanical engineering, engineering workshop practice or automobile engineering would be an advantage. Appropriate technical qualifications are expected.

AN ASSISTANT, GRADE A, IN ENGINEERING SUBJECTS

The teaching duties will be primarily in connection with mechanical and/or electrical engineering craft courses for engineering apprentices from the mining and engineering industries and the motor trade. Candidates should have had some industrial experience in one or more of the above, and previous teaching experience is desirable. Appropriate technical qualifications are expected.

The salaries will be in accordance with the Burnham Technical Scales, viz., Grade B, £490 by £25 to £765 per annum; Grade A, £415 by £18 to £670 per annum. Additions may be made to the scale for certain qualifications and study training. The position on the scale is determined by previous teaching and industrial experience.

Forms of application may be obtained from the Divisional Education Officer, Market Place, Mansfield, Notts, to whom they should be returned within 14 days of the appearance of this advertisement.

J. EDWARD MASON,
Director of Education.

County Hall, Nottingham. E9688

COLLEGE OF TECHNOLOGY, BIRMINGHAM

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

LECTURER

Applications are invited for the following post:—

LECTURER in the Mechanical Engineering Section of the Department for Higher National Certificate and External Degree work.

Candidates should have an Honours Degree or equivalent qualification in Mechanical Engineering, teaching experience and, preferably, some research experience.

Salary will be in accordance with the Burnham (Further Education) Scale for Lecturers (Men), £940 by £25 to £1040.

Further particulars and forms of application may be obtained from the Registrar, College of Technology, Suffolk Street, Birmingham, 1, on receipt of a stamped, addressed foolscap envelope. Completed forms should be returned not later than two weeks after the appearance of this advertisement.

K. R. PILLING,
Clerk to the Governing Body.

E9639

PUBLIC APPOINTMENTS

UNIVERSITY COLLEGE OF THE GOLD COAST

POWER STATION SUPERINTENDENT

Applications are invited for appointment as POWER STATION SUPERINTENDENT. Candidates must have had suitable education and training and have considerable experience in the running and maintenance of diesel engines and electrical generators.

Salary, £1100 per annum; F.S.S.U. or equivalent gratuity; appointment five years initially; family allowance at the rate of £100 per child (maximum £300); free passage for appointee, wife and maximum of three children; outfit allowance of £60 on first appointment; annual leave in the United Kingdom.

Applications, six copies, naming three referees and stating age and year by year education, qualifications and experience, to be sent before 9th August, 1954, to the Assistant Registrar (London), University College of the Gold Coast, 29, Tavistock Square, London, W.C.1. E9621

KUMASI COLLEGE (GOLD COAST COLLEGE OF TECHNOLOGY, SCIENCE AND ARTS)

LECTURERS

Applications are invited for the following posts:—

SENIOR LECTURER IN CIVIL ENGINEERING.

SENIOR LECTURER IN ELECTRICAL ENGINEERING.

LECTURER (Grade A) in ELECTRICAL ENGINEERING (Radio and Telecommunications).

Teaching will be up to Degree standard. Qualifications: Degree and membership of appropriate professional engineering Institution; industrial and/or teaching experience desirable.

SENIOR LECTURER in BUILDING, to teach senior staff in the building industry and to carry out research on building materials and methods in W. Africa. Qualifications: L.I.O.B. or H.N.C. in Building, experience in building industry and in teaching building subjects.

LECTURER (Grade A) in WORKSHOP PRACTICE, to teach students in professional engineering and in technicians courses. Qualifications: H.N.C. in Production Engineering, Corporate Membership of I.P.E., and practical experience in responsible post in engineering works.

Now in the early stages of development, the College is autonomous, complementary in function to the University College of the Gold Coast, and of comparable status. It has at present about 600 resident students and will eventually accommodate up to 2000.

Salary scales:—

Senior Lecturers	£1400–£1850 p.a.
Lecturers (Grade A)	£880–£1560 p.a.

Initial salary according to experience. Posts are pensionable, but temporary appointments carrying gratuity and 10 per cent higher salary could be made if preferred. Partly furnished houses provided, rent £60–£120 p.a., according to salary. Free first-class passages for persons appointed, their wives and up to 3 children under 13. Generous home leave, normally annual, on full salary.

Write for further information to Secretary, Advisory Committee on Colonial Colleges, 1, Gordon Square, London, W.C.1. Closing date for applications (6 copies), 10th August, 1954. E9632

QUEEN MARY COLLEGE

LECTURESHIP IN MECHANICAL ENGINEERING

Queen Mary College (University of London), Mile End Road, E.1, invites applications from University Graduates for a LECTURESHIP IN MECHANICAL ENGINEERING, commencing in October, 1954.

Applicants should have had industrial engineering experience and also experience in research. Salary scale £600–£50–£900: £900–£50–£1150, with F.S.S.U. participation and family allowance of £50 for each child. Initial salary £600–£800 depending on qualifications.—Application forms (obtainable from the Registrar) should be returned by July 31st. E9589

CIVIL SERVICE COMMISSION

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

PRINCIPAL SCIENTIFIC OFFICER

The Civil Service Commissioners invite applications for a pensionable post in the Mechanical Engineering Research Laboratory (Materials Division), East Kilbride, Glasgow.

Duties: to lead a team determining the mechanical properties of materials, studying fatigue, and examining machine parts which have failed in service.

Candidates must have been born on or before 31st December, 1922, and have First or Second-Class Honours Degree in Engineering, or equivalent, but a candidate of outstanding ability without these qualifications may be considered. Knowledge of French and/or German and experience of committee work advantageous. Inclusive annual remuneration £1122–£1516 (men), £1007–£1354 (women). Exceptionally a starting salary above the minimum may be granted according to qualification and experience.

East Kilbride is one of the New Towns and favourable housing prospects exist for married staff.

Further particulars and application forms from Civil Service Commission, Scientific Branch, 30, Old Burlington Street, London, W.1, quoting No. S4356/54. Application forms to be returned by 12th August, 1954. E9684

PUBLIC APPOINTMENTS

DEPUTY PRINCIPAL

GOVERNMENT TECHNICAL INSTITUTE, BRITISH GUIANA

DEPUTY PRINCIPAL required by the Government Technical Institute, British Guiana, for appointment on contract for three years in the first instance. Salary, &c., £1050 a year. Gratuity at the rate of £225 a year. Free passages, liberal leave on full salary. Candidates must hold a C. and G. Full Technological Certificate or H.N.C. in Electrical or Mechanical Engineering or a similar qualification, and have had wide industrial and teaching experience. They must be able to undertake lectures at all levels up to the standard of the H.N.C. and the examinations for the Professional Institutions.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2A/30288/EH. E9593

PRISON COMMISSION

CIVILIAN INSTRUCTIONAL OFFICERS

(a) BLACKSMITH/FITTER required at H.M. Prison, The Verne, Portland, and (b) FITTER MACHINIST required at H.M. Borstal Institution, Portland, Dorset. Both instructors will be required to act as relief at other prisons when necessary. Candidates must be at least 30 and under 50 on 3rd August, 1954. For post (a) candidates should have served an apprenticeship and obtained a City and Guilds Certificate or equivalent in blacksmiths' and mechanics' work. They must be able to instruct prisoners in modern methods of production by hand and power hammer, experience in the use of oxy-acetylene welding plant essential. Candidates for post (b) should have served an apprenticeship and obtained a City and Guilds Certificate or equivalent in Machine Shop engineering. Must be capable of giving theoretical and practical instruction in fitting and machine shop practice. Preference will be given to applicants with a knowledge of motor mechanic work.

Annual salary £550 by four annual increments to a total of £640 inclusive, payable monthly; 44-hour-week; 18 working days paid annual holiday, rising to 24 days after three years' service; quarters not provided. Appointment unestablished (non-pensionable), but establishment considered after period of satisfactory service.

Application forms, returnable by 30th July, 1954, may be obtained from Establishment Officer (R212/112 E), Prison Commission, Horseferry House, Dean Ryle Street, London, S.W.1. Candidates should state for which post they wish to be considered. E9591

WAR DEPARTMENT

SHIFT ENGINEERS (ELECTRICAL AND MECHANICAL)

Applications invited from SHIFT ENGINEERS (Electrical and Mechanical) for service in Egypt. Candidates should have Ordinary National Certificate in Electrical or Mechanical Engineering or evidence of an equivalent standard of technical education, five years' apprenticeship or its equivalent with an engineering concern giving comprehensive training, at least three years' experience in operation of H.T. and L.T.A.C. power station electrical plant and switch gear and be able to supervise native switchboard attendants, or at least three years' sound training and experience in control and operation of modern medium-sized diesel electrical generating plant and auxiliary equipment and be able to supervise native engine drivers. Appointment is for two years in first instance (one or two years in the case of electrical engineers) with possibility of extension and candidates must be prepared to complete tour unaccompanied by families. Starting pay will be fixed according to age, qualifications and experience on a range of £540 to £670. Foreign service allowance up to £458 a year, according to individual circumstances, may be payable in addition. Both salary and F.S.A. at present free from United Kingdom income tax (schedule E). Candidates who must be British and of British parentage, should apply to any Employment Exchange, quoting O.M.P. 809/54 or O.M.P. 809/2/54. E9630

BRITISH ELECTRICITY AUTHORITY

HEADQUARTERS

DRAUGHTSMEN

British Electricity Authority, Headquarters, Bankside, London, require DRAUGHTSMEN for work on either:—

(a) Civil and building works in connection with outdoor grid substations, or

(b) Electrical layouts and diagrams for grid substations.

Salary: N.J.B., Grade 6, Schedule "D," £458 to £595 (inclusive), according to qualifications and experience. Pension scheme. One Saturday morning in four on duty.

Forms from D. Moffat, Director of Establishments, Winsley Street, W.1. Quote Ref. AE.491. E9632

DEPARTMENT OF ATOMIC ENERGY

ENGINEER GRADE I

ENGINEER, Grade I, required by Department of Atomic Energy, to be responsible to a Chief Engineer for preparation of schemes for modifications to increase efficiency of existing processes on chemical plant. Work entails close contact with operating, research and maintenance staffs. Qualifications: recognised engineering apprenticeship with Corporate Membership of a Senior Engineering Institution and experience of design or maintenance of chemical plant. An Honours Degree in Engineering may be an advantage. Salary, £1295–£1476. Superannuation scheme. House in reasonable time, if married. Application forms from Department of Atomic Energy, Industrial Group Headquarters, Risley, Warrington, quoting 635. E9633

PUBLIC APPOINTMENTS

BRITISH ELECTRICITY AUTH

LONDON DIVISION

DRAUGHTSMEN

DRAUGHTSMEN required by British Authority, London Division. Applic invited for the following superannu Conditions of service in accordance w Agreement, Schedule D. Salary includ allowance. Technical training up to Hig Certificate for posts (a) and Ordinary Certificate for posts (b). Practical traini or experience on site an advantage.

(a) SENIOR DRAUGHTSMEN, ANICAL ENGINEERING, with experi preparation of engineering drawings the design, layout and construction generating stations. To include one or following sections:—Boilers, fuel han alternator and condensing plant, C.W. feed and L.P. piping, auxiliary plant, Grade 4=£704 11s./£819, or Grade £704 11s. p.a.

(b) ENGINEERING DRAUGHTSM ANICAL ENGINEERING, with experi preparation of drawings associated with and construction of modern generating be able to prepare under supervision final drawings. Salary, Grade 6=£458/£595

(a) SENIOR DRAUGHTSMEN, EL ENGINEERING, with experience in the of engineering drawings associated with layout and construction of the electrical modern generating station, including the —H.T. and auxiliary switchgear, transformers, motors and starters, associated cable schedules, &c. Salary, Grade £704 11s. p.a.

(b) ENGINEERING DRAUGHTSM TRICAL ENGINEERING, with experi preparation of drawings associated with and construction of modern generating To be able to prepare under supervision working drawings. Salary, Grade 6=£ p.a.

(a) SENIOR DRAUGHTSMEN, STRUCTURAL ENGINEERING, with in the preparation of working drawings the construction of modern generating either of the following sections:—(a) details of reinforced concrete for main buildings, roads, river works, &c.; (b) details of heavy structural steelwork for ings, &c. Salary, Grade 5=£595 7s./£70

(b) ENGINEERING DRAUGHTSM STRUCTURAL and ARCHITECTU experience in the preparation of drawing in the construction of modern generating either of the following sections:—(a) concrete, (b) structural steelwork, (c) details of main and ancillary buildings. to prepare under supervision the final drawings. Salary, Grade 6=£458/£595

Applications, stating age, qualifications rience, to the Divisional Secretary, Britis Authority, London Division, Generat Great Portland Street, London, W.1, wi of this advertisement.

METROPOLITAN WATER B

APPOINTMENT OF CIVI ENGINEERING ASSISTAN

CIVIL ENGINEERING ASSISTA Two in salary scale £663–£717; (b) Tw scale £487–£636, are required in the Chief Department on the permanent, pensionab

For (a) applicants must be Corporate the Institution of Civil Engineers. Ex civil engineering and building construc supply of water from wells will be an adv

For (b) applicants must have passed or from passing Sections A and B or Final II of the examinations of the Institution Engineers.

Commencing salary according to age qualifications and experience. Further of the conditions of appointments will be interviews or on request. Applicat particulars of technical education, qualifi experience, together with the names an of two persons to whom reference may should be addressed to the Chief Engineer reach the Board's offices not later than 1954.

Canvassing disqualifies and relationship member, officer or employee, must be di

W. S. CHEVA
Clerk of the

Metropolitan Water Board,
New River Head,
Rosebery Avenue,
London, E.C.1.

LONDON ELECTRICITY B

WALTHAMSTOW DISTRICT O NORTH EASTERN SUB-AR

ENGINEER (OPERATION A MAINTENANCE)

Applications are invited for the above the Walthamstow District of the Nor Sub-Area.

Applicants should possess good techn fications and have had experience in sys tion, high-voltage and low-voltage mains in the maintenance of substation and chambers.

The post is graded under Schedule " National Joint Board Agreement as Clas 9—£637 7s. per annum, rising to £660 9s. inclusive of London allowance.

Application forms, obtainable from Officer, 46/7, New Broad Street, E.C.2, to completed within ten days of the publica advertisement. Please enclose address and quote ref. V/1768/EE on all correspon

THE ENGINEER

JULY 16, 1954

Gas and Electricity Supply Industries

IN moving the second reading of the Gas and Electricity (Borrowing Powers) Bill in the House of Commons last week, the Minister of Fuel and Power, Mr. Geoffrey Lloyd, said that the Bill would increase by large amounts the borrowing powers of these industries and thereby exercise a controlling influence on their capital investment in the next six years. The borrowing limit of the electricity supply industry would be raised from £700 million to £1400 million, and of gas from £250 million to £450 million. Mr. Lloyd said that, because of its fundamental importance, pride of place must go to atomic development. It was possible that, if these developments progressed as quickly as they had grounds to hope, the design and, perhaps, construction of nuclear power stations of an advanced type would be undertaken before 1960. In preparation for this possibility the British Electricity Authority was establishing a nuclear power branch in its engineering department. (Two days ago it was announced that Mr. J. C. Duckworth, chief engineer of the Ferranti Laboratories, Wythenshawe, had been appointed nuclear power engineer to organise and lead the new branch of the B.E.A. chief engineer's department, which would be engaged in the design, construction and operation of nuclear power stations.) Mr. Lloyd went on to announce the composition of an independent inquiry that had been instituted into the working of the electricity supply industry. The inquiry would be presided over by Sir Edwin Herbert : with him would be associated Mr. F. C. Bagnall, managing director of British Nylon Spinners ; Professor Ronald S. Edwards, an economist ; Mr. Albert Healey, director of the Dunlop Rubber Company, Ltd.; Mr. Lawrence Robson, an accountant, and Mr. Jack Tanner. Referring to the gas industry, Mr. Lloyd said that great progress had been made in the development of a catalytic process for making town's gas directly from fuel oil, without the use of coal. Two processes had been developed, one by the West Midlands Gas Board, in Birmingham, and the other by the South Eastern Gas Board, in Sydenham. Each of the gas boards had decided to install at least one such plant, and some thirteen installations were either under construction or out to tender. When they were in operation in some two years' time, they would have a capacity of 22,000,000 cubic feet, which would mean a yearly saving of about 400,000 tons of good carbonisation coal, with the prospect that wider development of the process would bring about much bigger savings of carbonisation coal in future years.

British Steel Castings Research Association

THE first annual general meeting of the British Steel Castings Research Association was held at York on Tuesday, July 13th. This association was incorporated last year when it assumed full responsibility for all co-operative research within the steel founding industry, which had, up till that time, been the concern of its predecessor, the Research and Development Division of the British Steel Founders' Association. Some three-quarters of the industry in terms of tonnage production support the association, which recently accepted a grant aid from the Department of Scientific and Industrial Research. As part of its first five-year programme, the association proposes to set up, in Sheffield, a fully-equipped foundry experimental station, so that the results of its laboratory researches can be carried forward to a stage of practical development when they can be applied directly on a production basis in member firms' foundries. Following the annual general meeting, there were presented a series of demonstrations, by means of models, &c., of the association's activities during the past year. The demonstrations included an exhibit of an air-carbon-arc torch, designed to replace the pneumatic chisel in certain applications. The use of radio-active materials in a study of the factors affecting the freezing of steel was also shown. A working model showed the association's dust control device on a swing frame grinder, and particulars were given of a new and more rapid non-destructive technique of testing steel castings, based upon the use of a scintillation counter.

Cafeteria-Restaurant Cars on British Railways

A NEW form of combined cafeteria-restaurant car, the first of which was recently introduced into service on British Railways, is designed for serving either set meals or light refreshments from the one coach continuously throughout a journey. These new cars are being equipped at Eastleigh works and each weighs 35 tons and is 61ft 6in long. It is planned to introduce twenty-seven of the cars into service at present and the first were used on July 12th on the 1.35 p.m. train from Nottingham to St. Pancras and the 7.10 p.m. from St. Pancras to Derby. As other cars become available they will run between St. Pancras and Bradford, Sheffield, Manchester, Glasgow and Edinburgh. In the new cars the kitchen is situated between an eighteen-seat restaurant compartment and a cafeteria section, having, down the centre, a table at which nine people can sit on stools. In the restaurant full meals are available with waiter service, whilst drinks and snacks are obtainable from a self-service counter in the cafeteria. The kitchen is fully equipped with hot plates, grill, hot cupboards, sink, a deep-freeze refrigerator, &c., all constructed on hygienic and compact lines to give maximum availability whilst leaving adequate room for the staff to move about in.

Higher Technological Education

THE Chancellor of the Exchequer, Mr. R. A. Butler, made a statement in the House of Commons on Tuesday about higher technological education. In the course of it he said that a year ago he invited the University Grants Committee, in consultation with the universities and colleges concerned, to work out plans for the development of higher technological education outside London. At the same time, he informed the committee that the special effort which the Government had in mind would have to be contemplated in a small number of places, though normal developments elsewhere would not be ruled out. The Chancellor went on to say that the University Grants Committee had now examined proposals submitted by universities and colleges, and after considering the committee's recommendations he had approved plans for developments outside London in which the main centres would be Glasgow, Manchester, Leeds and Birmingham, but in which provision was also made for development elsewhere. Those developments, the Chancellor stated, would take place at institutions already in receipt of recurrent grants on the committee's recommendation. To increase the number of university institutions concerned with higher technological education would involve a dispersal of effort which the committee did not advise, and it had therefore been unable to recommend a change in the status of the Bradford Technical College. The implementation of the plans, the Chancellor added, and of those for the Imperial College of Science and Technology, would necessitate some increase in the resources available to the University Grants Committee, both for recurrent and non-recurrent purposes, in the last three years of the quinquennium 1952–57. The timing of those developments was now being considered, but he hoped that some of them would start in the next academic year.

Reorganisation Scheme for British Railways

A WHITE PAPER just issued contains the British Transport Commission's new railway reorganisation scheme. In preparing the scheme twenty-one bodies representative of industry, labour and local authorities were consulted, and it is stated there was a wide measure of agreement by those bodies. The scheme aims at decentralising management and control whilst the British Transport Commission would remain the supreme policy-making body. It proposes that boards should be set up as area railway authorities under the Act. The members of the boards, although not representing particular interests, would contribute a close knowledge of public and business requirements and would improve personal contact with the staff. Each board would consist of a maximum of seven part-time members and one or more should be a member of the Commission. An area board would be responsible for the general supervision of the railway system within its area, promoting initiative for improving the service ; effecting economies ; submitting budgets and forecasts of capital and revenue expenditure ; exercising certain powers in regard to approval of expenditure, appointments, &c.; maintaining contact with railway users, and encouraging good relationships and loyalty amongst the staff. A Chief Regional Manager would be appointed for each area for the day-to-day management and to maintain close contact with the Commission's headquarters. Initially, it is proposed that the six existing Regions of British Railways should be established as areas, but the Commission asks that it should be given freedom to make any necessary adjustments in the light of experience.

London Transport Exhibition

To mark its twenty-first anniversary, London Transport has arranged an interesting exhibition at Charing Cross Underground Station, to show some aspects of its work which the general public does not normally see. The exhibition was opened on Monday last by Sir John Elliot, chairman of London Transport, who said that for the first five weeks it would deal with the railway side of the organisation, and then be changed over to deal with the road transport side. An interesting group of working exhibits has been arranged from standard components and equipment, most of which can be operated by the public, and are clearly labelled to show their particular functions. There is a full-sized model of an underground driver's cab, complete with controller handle and electro-pneumatic brake which are so arranged that their 'operation can be seen on a train wheel. A 25ft section of typical rail track is equipped with a representative selection of modern devices. Depression of a button swings over a set of points, whilst appropriate colour light signals and route indicators change their aspect, electrical relays operate and an automatic trainstop comes into the operative position. An oil-electric point heater for frosty weather is fitted, together with an anti-freeze rail bath. A guard's control panel is arranged by the side of a pair of automatic car doors, and when the buttons are depressed the operation of the door motors and closing equipment can clearly be followed. One model of particular interest shows graphically the layout of the tunnel and escalator system at Charing Cross station. Other models show the switchboard of a substation control room, an escalator, and a ticket machine.

Behaviour of Water Globules in Steam

By DENIS J. RYLEY, M.Sc. (Eng.) (Lond.), A.M.I.Mech.E.*

Because of experimental difficulties, the behaviour of small water globules entrained in wet saturated steam has received scant attention. This article attempts to cover briefly the essentially dynamical aspects of globule behaviour from a theoretical approach. The treatment deals with the size, trajectory, drift velocity ratio and general movements of globules. Attention is given to the fracture of globules and a new kind of chart is described for finding the wind velocity necessary to break an undeformed spherical globule under specified conditions. The theoretical work gives some useful hints concerning the practical design of mechanical driers using the inertia principle.

THE behaviour of small solid particles entrained in a liquid or gas is of interest to engineers in many branches of the profession. The term "micromeritics" has been suggested (Dallavalle, 1948)[1] for the technology which treats of the general dynamics of suspended particles. An unexplored branch of micromeritics is concerned with the behaviour of wet saturated vapours, but this branch differs from that concerned with, say, suspensions of sand in water, inasmuch as one element only is present, although in different phases. In the field of wet saturated vapours there is an almost complete lack of organised knowledge on the dynamical as distinct from the thermodynamical side, and this arises from three major difficulties which seriously impede experimental work :

(*a*) The particles, being liquid globules, have a transitory existence. The statistical size distribution under any given set of conditions, a knowledge of which is basic for any rigorous quantitative treatment, cannot be obtained by any of the standard methods of particle size determination, i.e. direct measurement with sieve or microscope, sedimentation, elutriation or centrifuging.

(*b*) Size changes can and do occur for both dynamic and thermodynamic reasons and may take place with extreme rapidity, particularly with minute globules.

These difficulties are enhanced by irregular behaviour which occurs when the thermodynamic state is near the phase boundary. Thus supersaturation may temporarily inhibit condensation and liquid globules may persist for some time in a superheated atmosphere. With those branches of micromeritics concerned with mixtures of different substances none of these difficulties occur.

In spite of these obstacles it is possible, by drawing on knowledge from many fields, to build up a coherent picture of the nature and behaviour of the suspended globules.

Symbols.

d—Diameter of globule.
d_c—Critical diameter of globule at fracture.
V_s—Local linear velocity of steam.
V_g—Local linear velocity of globule.
$f=V_w/V_s$—Drift velocity ratio.
$V_w=V_s-V_g$—Horizontal relative velocity of globule.
V_v—Descent velocity of globule.
V—Resultant velocity from V_w and V_v.
$(V_s-V_w)_c$—Critical relative velocity at fracture.
V_i—Initial descent velocity of globule.
$\rho_s=1/v_s$—Density of saturated steam.
$\rho_w=1/v_w$—Density of saturated water.
C_d—Coefficient of drag.
$A=\pi d^2/4$—Projected area of globule.
R—Aerodynamic resistance.
V_T—Terminal velocity.
μ—Viscosity of saturated steam.
$\nu=\mu/\rho$—Kinematic viscosity of saturated steam.
$m=\pi d^3\rho_w/6$—Mass of globule.
t—Time.
g—Gravitational constant.
p—Pressure.
p_A—Atmospheric pressure.
Δ—Molecular diameter of steam.
l—Molecular mean free path in steam.
σ—Surface tension of water-steam interface.
s—Displacement.
t_s—Saturation temperature.
Re—Reynolds number.

1ft=30·5cm=30·5×10⁴ microns.

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Probably the most important case in engineering is the case of steam, and the material presented hereafter refers specifically to steam. If, however, the appropriate numerical physical constants are substituted, the methods are applicable to most vapours.

Size of Globules

It is convenient to divide globules into three distinct grades according to their size :

(1) *Clusters or Aggregates.*—The smallest size of globule is that containing two molecules. When a globule contains very few molecules it exhibits none of the effects usually associated with large globules, such as viscosity, surface tension, an equilibrium vapour pressure or any phenomenon which is basically statistical. If the number of molecules exceeds about 100 to 150, corresponding to a diameter of about $6\cdot6\times10^{-9}$ft (2×10^{-7}cm), the globule begins to exhibit these properties and becomes different in kind from the smallest aggregates. Following Rodebush (1949),[2] the term "cluster" should be reserved for the case where the number of molecules is less than 100 to 150. Rodebush has pointed out that the liquid entropy curve shows a minimum value in this region and this gives a physical basis for the choice of a size boundary.

(2) *Droplet.*—The term "droplet" will be used to describe globules which are larger than 100 to 150 molecules and are therefore similar in their general physical behaviour to globules of all sizes up to those in the macroscopic range. The term may be taken to apply to all cases where the diameter lies in the range $6\cdot6\times10^{-9}$ft (2×10^{-7}cm) to 10^{-3}ft (0·03cm). There is no natural physical criterion (unless it be the resolving power of the eye) to form an upper boundary to this size group, and the limit is fixed arbitrarily. Droplets have a high ratio of surface to volume and are structurally very stable. They are difficult to deform and very difficult to fracture. They attain their terminal velocities of fall rapidly and these velocities are very small.

(3) *Drops.*—Any discrete portion of the liquid phase having a closed interface and a volume exceeding that of a sphere 10^{-3}ft diameter may be referred to as a drop. Drops are structurally weak, liable to fracture, show deformation and inertia effects and fall rapidly out of suspension.

Out of the total globule population of wet steam, drops form a very small percentage indeed in any circumstances. In wet steam expanding in nozzles they are absent except in a few extreme cases. They have a transitory existence in mains carrying wet or saturated steam and in the low-pressure stages of turbines.

The formation diameter of clusters precipitated after a supersaturation ratio of about 8 is approximately 10^{-9}ft to 10^{-8}ft (3×10^{-8}cm to 3×10^{-7}cm) as determined by light scattering methods (Yellot, 1934[3] ; Yellot and Holland, 1937[4] ; Rettaliata, 1936[5]). There is no evidence to show that the formation size is a function of the supersaturation, and it may be assumed that all clusters condensing free of existing surface are of this size. This size is within the colloid range and larger clusters obey most of the laws of colloid systems in respect of diffusion, optical effects, Brownian movement and sedimentation. Clusters may grow or fail to grow beyond a critical size at which they are capable of initiating further spontaneous growth in an atmosphere showing some degree of supersaturation (La Mer, 1952[6]). Their growth up to this critical value and their subsequent dissociation if they fail to pass it arise from a stepwise bimolecular addition or loss. The many that do grow beyond the critical size continue their growth to become droplets, and if conditions are favourable they will ultimately become drops. Failure to grow beyond this critical size has been observed by Yellot, and his estimate of $6\cdot2\times10^{-6}$cm globule diameter is in satisfactory agreement with the known value for critical cluster diameter.

Drops and droplets grow either by coalescence with other globules or by surface deposition consequent upon further condensation. A tendency is always present whilst supersaturation persists for large globules to grow at the expense of small ones. Drops and droplets never return to cluster dimensions as a result of mechanical agencies, only as a consequence of re-evaporation. Whilst it is well established that clusters will grow by agglomeration at least to the critical radius, certainty of growth cannot be claimed for droplets and drops. The work of Derjaguin and Prokhorov (1946)[7] suggests that droplets and drops will usually coalesce upon impact in an atmosphere of their own vapour and this fact is important in connection with mechanical precipitation. Because clusters and small droplets as such cannot be separated from dry steam by inertia effects, they must first be induced to grow by coalescence.

It may be pointed out that problems of nucleation, cluster growth and so on belong to the domain of chemical thermodynamics, and for detailed information the reader should consult a symposium,[8] where an account of the modern state of knowledge may be found.

Globule growth, when the steam is in transit through a nozzle and thus in an atmosphere whose characteristics show unusually rapid change, presents additional problems, and a method of approximate treatment which agrees passably with experiment was attempted by the writer[9] in an earlier issue of this journal.

Trajectory of Globules

On account of their minute size the motion of clusters is not predictable. It arises from Brownian movement and is random in magnitude and direction. As the size order becomes greater, and Brownian movement dies out, the laws of dynamics of macroscopic particles become increasingly true. Droplets, on account of their great structural stability, assume and preserve a spherical shape and will only abandon it if V_s-V_w reaches a considerable value. It is possible, therefore, to regard a droplet as a rigid sphere and thus utilise a vast range of data from existing knowledge in gas dynamics. For a sphere, wind tunnel work shows that the aerodynamic resistance is given by

$$R=\frac{\rho_s}{2}\cdot(V_s-V_w)^2\cdot C_d\cdot A \quad . \quad . \quad (1)$$

The coefficient of drag, C_d, is a function of the Reynolds number Re, defined as :

$$Re=(V_s-V_w)d\,.\,\rho_s/\mu \quad . \quad . \quad . \quad . \quad (2)$$

The curve relating C_d and Re is given in Fig. 1, which represents the mean of experimental results due to many workers.

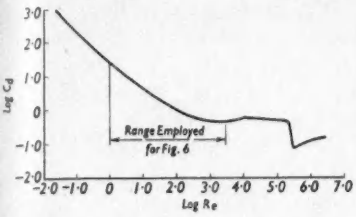

Fig. 1—Drag coefficient for sphere

For two-dimensional motion of a droplet in free flight, the situation is as shown in Fig. 2. Suppose the steam is travelling to the left with a uniform velocity V_s, and the

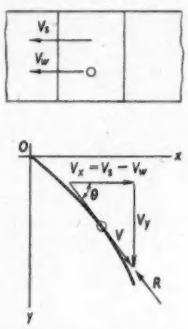

Fig. 2—Motion of a droplet

droplet with a uniform velocity $V_w<V_s$. Suppose, also, that the droplet is falling under gravity with a velocity V_y. Then,

$$m\,.\,\frac{dV_x}{dt}=-R\cos\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$m\,.\,\frac{dV_y}{dt}=mg\left(\frac{\rho_w-\rho_s}{\rho_w}\right)-R\sin\theta \quad . \quad . \quad . \quad (4)$$

Substituting (1) in (3) and (4) and adjusting

$$\frac{dV_x}{dt}=-\frac{\rho_s\,.\,VV_xC_d\pi d^2}{8m} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$\frac{dV_y}{dt}=g\left(\frac{\rho_w-\rho_s}{\rho_w}\right)-\frac{\rho_sVV_yC_d\pi d^2}{8m} \quad . \quad . \quad (6)$$

Neither (5) nor (6) are capable of direct solution, but may be solved approximately using finite intervals.

A rigorous treatment of the dynamics of drops presents grave difficulties on account of the deformation undergone with rise in f. Not only is the instantaneous shape of a deforming drop unknown, but no information exists concerning the probable values of C_d. The nearest approach yet made by experimenters is in respect of ellipsoids. Fortunately, the smaller drops are sufficiently rigid to be considered as droplets, whilst the larger ones have a very short life. Nevertheless, their behaviour in flight is of interest to engineers engaged on the design of direct contact heat exchangers, in which alien drops are introduced into the steam atmosphere, and further mention is made of them later.

Drift Velocity Ratio

It is not possible to make direct experimental measurements of globule velocity and very few theoretical inquiries have been attempted. A globule will adjust its relative velocity, V_s-V_w, when moving horizontally, until the aerodynamic force just balances the frictional resistance. As the smaller globules have surfaces devoid of ripples, the frictional resistance will be very small, and it is safe to infer that f will approach unity very closely except where abrupt changes in velocity occur, as, for example, when shock waves are encountered, or the main flow undergoes a sudden change of direction. The case of nozzles providing rapid expansions constitutes an intermediate case between steady flow and abrupt shock. Goodenough (1927)[10] calculated the theoretical variation of f through a nozzle and gave it approximately constant at 0·12. The value is probably much higher than this as consideration of the following facts will show. In his work on supersaturation, Yellot[3] estimated by optical observation that where the pressure was 15 lb per square inch the droplet size was of the order 4×10^{-6}ft ($1\cdot2\times10^{-4}$cm) diameter. Assuming the accuracy of the fracture curves to be treated hereafter, a droplet of this size cannot survive if $V_s-V_w>140$ft per second. The steam velocity for the nozzle section observed may be estimated as 2000ft per second approximately, giving a value of f which must be at least $(2000-140)/2000=0\cdot93$.

The value of f is only directly of interest when the impact of wet steam on an impulse plate is considered in connection with the determination of velocity coefficients, in the calculation of discharge coefficients for nozzles with two-phase flow, and in connection with the erosion of low-pressure blading in turbines. In the first-named, the effect is negligible, whilst the second has been treated by the present writer[11] in an earlier article. The important case of the turbine will be mentioned later.

Descent of Globules

If in equations (5) and (6) V_x be disregarded and V considered equal to V_y an approach may be made analytically to the problem of sedimentation. There is no direct means of knowing the relative magnitudes of V_x and V_y in a given case and, therefore, the degree of approximation involved, but for steam in fairly steady flow where f may be very high, the error is probably small. For sedimentation from stationary steam there is no error.

Movements of globules of the size now under consideration are in most cases subject to Stokes's Law provided certain conditions are fulfilled. The minimum diameter to which Stokes's Law applies without a correction lies in the range 10^{-6}ft to 10^{-4}ft(3×10^{-5}cm to 3×10^{-3}cm), according to the pressure. For smaller values of diameter it becomes necessary to add a correction investigated mathematically by Cunningham (1910).[12] This correction is necessary because the concept of viscosity breaks down as the particle size approaches dimensions comparable with the mean free path of the fluid molecules. Owing to a reduction in the number of molecular impacts a minute particles may achieve a terminal velocity considerably in excess of the Stokes's Law value.

For spherical particles, if in equation (6) $V=V_y=V_T$ and $dV_y/dt=0$, then on simplifying the terminal velocity becomes

$$V_T=0\cdot0287d^2\left(\frac{\rho_w-\rho_s}{\mu}\right) \text{ for laminar flow.}$$

Applying Cunningham's correction this is modified to

$$V_T=0\cdot0287d^2\left(\frac{\rho_w-\rho_s}{\mu}\right)\left(1+\frac{1\cdot63l}{a}\right) \quad . \quad (7)$$

where l, the mean free path, may be determined with sufficient accuracy from

$$l=\frac{2\cdot02\mu}{\sqrt{p_A\rho_s}} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

In (8) p_A is one atmosphere equal to $1\cdot013\times10^6$ dynes per square centimetre and μ is the viscosity of dry saturated steam in c.g.s. units. There is reasonable convergence of opinion on the numerical value of μ for low pressures, but at high pressures two important schools of thought following respectively Sigwart (1936)[13] and Hawkins, Solberg and Potter (1935)[14] disagree. The quantity a in equation (7) may be taken as

$$a=\frac{d+\Delta}{2} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where Δ ,the molecular diameter of steam is given by Kaye and Laby (1948)[15] as 4×10^{-8}cm.

The upper limit of size to which Stokes's Law applies may be taken as

$$d=\sqrt[3]{\frac{36\mu^2}{\rho_s\cdot g(\rho_w-\rho_s)}} \quad . \quad . \quad . \quad (10)$$

due to Allen (1900).[16]

The curves given in Fig. 3 show the variation of saturation temperature, viscosity (Sigwart), mean free path and limiting upper size on a basis of pressure, whilst Fig. 4 shows the variation of Cunningham's correction, corrected terminal velocity and corresponding Reynolds number on a basis of globule size. In the interpretation of these latter curves it must be remembered that Re is a function of μ, which concept becomes increasingly vague with reduction in size and that the Re curves have, therefore, a decreasing validity as d decreases. Also, with regard to Cunningham's correction, as d approaches formation size so the cluster becomes increasingly subject to sudden chance movements, and this correction, together with the V_T curves, has a failing validity.

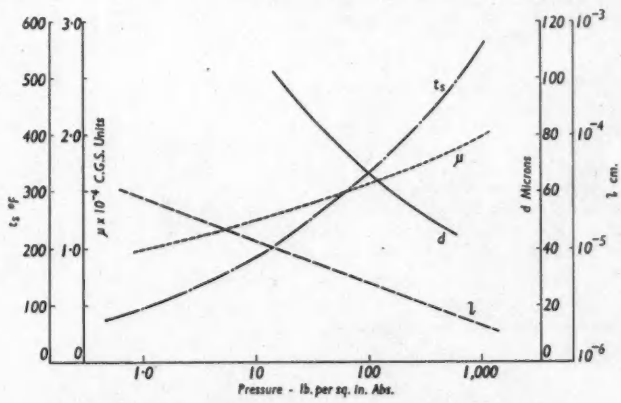

Fig. 3—Saturation temperature, viscosity, mean free path, and limiting upper diameter for Stoke's Law as functions of pressure for saturated steam

Reverting to equation (5), if $V=V_y$ and if $V_y=\mu Re/d\rho_s$, it may be shown that

$$\frac{\mu At}{2md}=\int_{R_0}^{R}\frac{dRe}{\phi-C_d\,.\,Re^2} \quad . \quad . \quad (11)$$

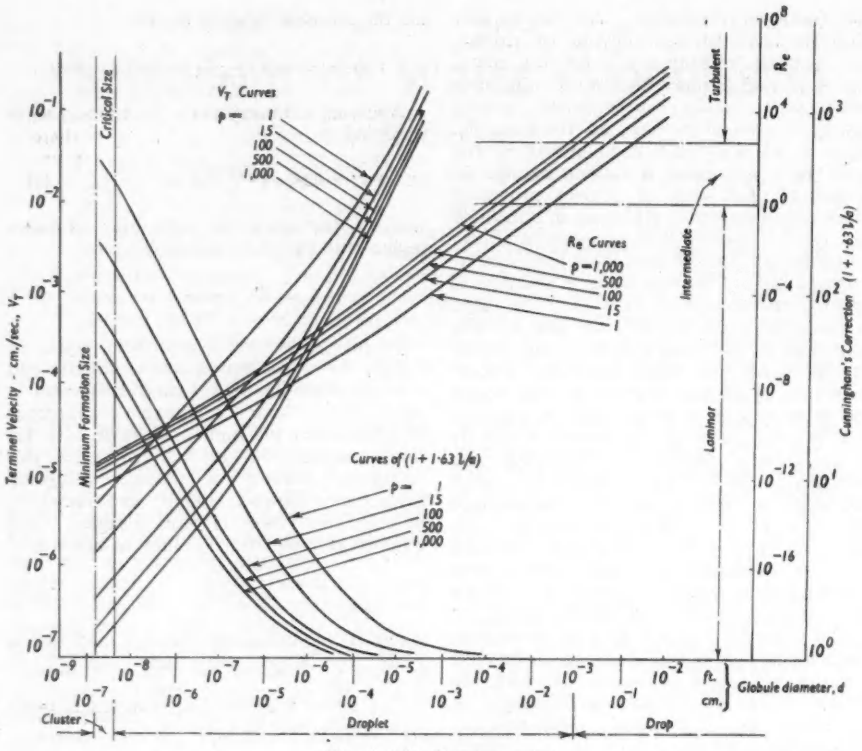

Fig. 4—Miscellaneous curves

where R_0 and R are the values of Re corresponding respectively to $t=0$ and $t=t$, and for a spherical globule

$$\phi=\frac{4g\rho_a(\rho_w-\rho_a)d^3}{3\mu^2} \quad . \quad . \quad . \quad (12)$$

To integrate equation (11) it is necessary to know the functional relationship connecting C_d and Re. As mentioned earlier, the experimental relationship shown in Fig. 1 is well established, and it has been pointed out (Dallavalle, 1948)[1] that for the whole span of the curve the following algebraic function gives a fair match :

$$C_d=\left[0\cdot63+4\cdot8/\sqrt{Re}\right]^2 \quad . \quad . \quad (13)$$

Integration of equation (11) is, however, rendered easier by restricting the range of integration to the three major regions. For the laminar region it may be taken that

$$C_d=24/Re \quad . \quad . \quad . \quad . \quad (14)$$

By equations (14) in (11), and after solution, one obtains

$$t=\frac{md}{12\mu A}\cdot\log_h\left(\frac{V_T-V_0}{V_T-V}\right) \quad . \quad . \quad (15)$$

and the distance travelled in time t is

$$S=V_Tt-(V_T-V_0)\left(\frac{md}{12\mu A}\right)\left(1-\exp.\left[\frac{-12\mu At}{md}\right]\right)$$
$$. \quad . \quad . \quad . \quad . \quad (16)$$

Owing to the exponential forms assumed by equations (15) and (16) t and S become infinity when $V=V_T$. For purposes of calculation, therefore, one may evaluate S and t for $V=$(say) $0\cdot9V_T$. This has been done and the results are as shown in Fig. 5 for the case where $V_0=0$. Equations (15) and (16) become invalid if $Re>2$, and for $Re<10^{-4}$ the concept of Reynolds number becomes obscure as explained above.

Drops and the largest droplets cross the laminar region boundary before attaining their terminal velocities. In such a case one may employ equations (13) in (11) for the whole range of movement. Alternatively, it is simpler to deal with the movement in each region separately. The laminar descent is dealt with as above, the limits of integration for equation (11) being $Re=0$ to 2. For the descent in the intermediate region, which may be taken to extend from $Re=2$ to 500, the experimental C_d-Re curve is conveniently represented by

$$C_d=0\cdot4+40/Re \quad . \quad . \quad . \quad (17)$$

For descent in this region the time increment is given by equations (17) in (11), which yields the solution

$$t=\frac{2\cdot5md}{\mu A}\cdot\frac{1}{\sqrt{(2\cdot5\phi+2500)}}\log_h\cdot\frac{Re+50+\sqrt{(2\cdot5\phi+2500)}}{Re+50-\sqrt{(2\cdot5\phi+2500)}} \quad . \quad (18)$$

for values of Re lying between $Re=2$ and that value which is defined when the globule achieves its terminal velocity. The value of the latter is given by Dallavalle[1] as

$$V_T=K_I\cdot\left(\frac{\rho_w-\rho_a}{\rho_a}\right)^{\frac{2}{3}}\cdot\upsilon^{-\frac{1}{3}}\cdot d_0 \quad . \quad . \quad (19)$$

where $K_I=14\cdot4$ c.g.s. units and d_0 is given by

$$d_0=d-0\cdot4\sqrt[3]{\left[\frac{36\mu^2}{\rho_a g(\rho_w-\rho_a)}\right]}\text{c.g.s. units} \quad . \quad (20)$$

The distance travelled during descent in the intermediate region presents difficulties and is probably best evaluated by plotting $V=Re\cdot\mu/d\cdot\rho_a$ against t in equation (18) and evaluating graphically $s=\int Vdt$.

It will be seen that for all pressures droplets smaller than 10^{-4}ft (3×10^{-3}cm) diameter substantially achieve their terminal velocities very quickly and travel very short distances whilst doing so, and that the effect of pressure on both time and distance is almost negligible. For the largest droplets and particularly for drops none of these conditions hold. Pressure becomes of increasing importance with increasing size of drop. For terminal velocities of drops in the size range 0·01in to 0·25in (8×10^{-4}ft to 2×10^{-2}ft) diameter, the reader is referred to the work of Weinberg,[17] who calculated values of V_T for this range on the supposition that the drops remained spherical and intact. The assumptions are probably valid for the lower part of the size range, but doubtful for the upper part.

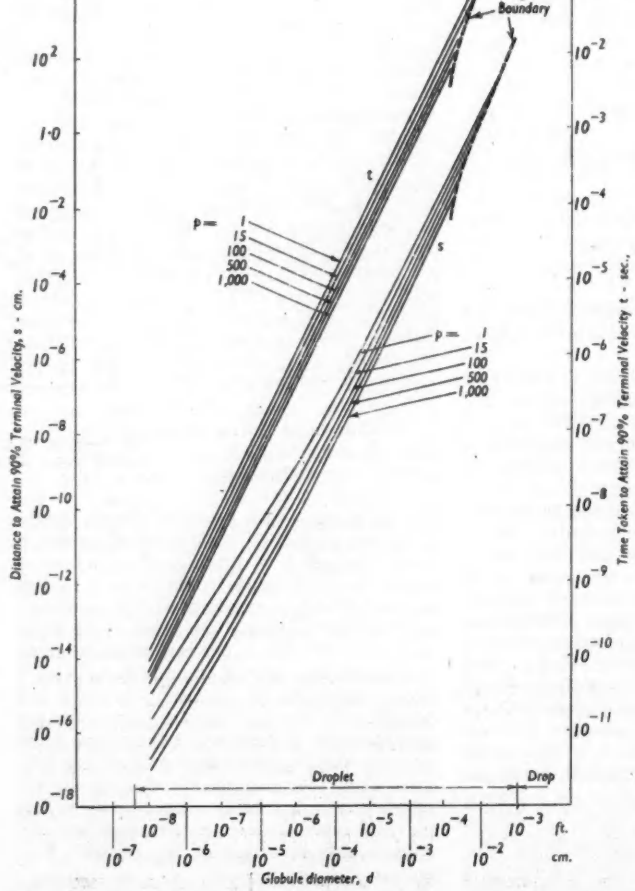

Fig. 5—Distance and time required to attain 90 per cent terminal velocity from rest with laminar descent

Drops of this size very seldom rise spontaneously by condensation and coalescence, but may occur as alien injected drops in direct contact heaters, &c.

Fracture of Globules

For a globule of any size, the physical conditions obtaining at the point of fracture may be visualised as follows. As the relative velocity V_a-V_w increases steadily, the stable spherical shape is abandoned and the globule elongates in such a manner as to offer minimum wind

resistance. In the supposed absence of skin friction, breakage will occur when the aerodynamic drag on the "tail" exceeds the surface tension over the circular section at which rupture occurs. Direct observation on large drops shows that the extension is considerable immediately before breakage, but the shape at fracture of smaller globules is not known. Special modes of fracture (Hochschwender, 1919[18]; Lane, 1951[19]) occur if large globules are exposed to a sudden blast, i.e. if $d(V_s-V_w)/dt$ is very large.

Clusters.—It may be assumed that clusters are immune from fracture, not by virtue of strength, but because of the impossibility of bringing a sufficient concentration of energy to bear on so small a body.

Droplets.—The same immunity applies to droplets of all but the largest size and for the same reason.

Drops.—Drops are susceptible to fracture, and the required values of $(V_s-V_w)_c$ are often encountered in practice.

Experimental work on the fracture of liquid globules in *air* has been extensive in the case of both fuel oil and water, principally in connection with the design of atomising devices.

For fuel oil, size distribution of globules has been examined by Keuhn (1924–5)[20]; Bird (1926–7)[21]; Underwood (1931)[22]; and Lee (1935)[23]; whilst the case of water has been treated by Doble (1945, 1947)[24]; Brown (1951)[25]; and Weinberg (1953).[17] In the case of oil, examination of the literature shows a broad convergence of opinion that the limiting lower size of globule lies in the range 10^{-5}ft to 10^{-4}ft (3×10^{-4}cm to 3×10^{-3}cm) diameter. For water, the smallest droplet that has been detected was about $3{\cdot}3\times10^{-6}$ft (10^{-4}cm) and was produced by a spray nozzle. For the characteristics of spinning disc water sprayers operating in air the reader may consult the work of Boshoff,[26] which includes earlier references.

No rigorous mathematical treatment exists for the deformed shape of a liquid globule at fracture, though attempts have been made by Triebnigg (1929)[27]; Heijler (1929)[28]; Klüsener (1933)[29]; Littaye (1943)[30]; and Hinze (1949).[31] There is some evidence to support the view that small globules fracture without substantial deformation, and if this is allowed it is possible to devise simple fracture charts based on equations (1), (2) and the following :—

$$C_d\cdot\rho_s(V_s-V_w)_c^2=\frac{8\sigma}{d_c} \quad . \quad . \quad . \quad (21)$$

which assumes breakage on a diametral plane perpendicular to the wind.

For a given pressure, ρ_s and, therefore, σ become constant, and a chart is needed for each pressure chosen. Axes are erected as shown in Fig. 6. *Re* is plotted against *d* for given values of (V_s-V_w) in the first quadrant from equation (2), and *Re* is plotted against C_d in the second, this curve being part of that of Fig. 1 and common to all charts. In the third quadrant, *d* is plotted against C_d for given values of (V_s-V_w), using equation (21). All axes are calibrated logarithmically and parameters in quadrants 1 and 3 are straight lines.

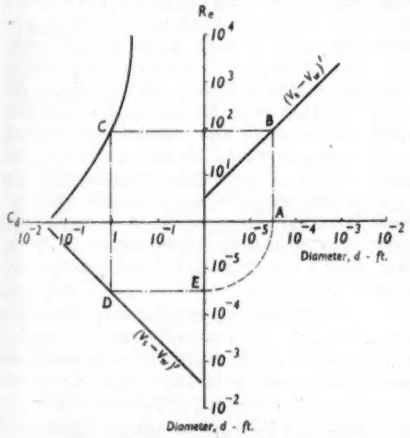

Fig. 6—Fracture chart

To obtain a solution it is necessary to select a diameter *A* and proceed to *B* on a chosen velocity line $(V_s-V_w)^1$. Perpendicular lines *BC*, *CD* and *DE* are erected, *D* being on $(V_s-V_w)^1$ in the third quadrant. If the values of *d* at *A* and *E* match, a solution has been obtained.

Using this construction, charts have been drawn out for $p=1$ lb, 15 lb, 50 lb, 100 lb, 200 lb and 500 lb per square inch absolute, each of which yields a set of corresponding values of $(V_s-V_w)_c$ and d_c. The results thus obtained have been plotted (Fig. 7), using *p* as parameter. It is seen that for any pressure two distinct regions are defined which may be referred to as the aerodynamic and atomisation regions respectively. Considering the latter, when the Stokes's region boundary is reached,

$$R=\pi d\sigma=3\pi\mu d(V_s-V_w)$$

$$(V_s-V_w)=\frac{\sigma}{3\mu} \quad . \quad . \quad . \quad . \quad (22)$$

Thus, (V_s-V_w) becomes independent of *d*. When (V_s-V_w) reaches this value it would seem that the globule undergoes complete and continuous atomisation to the original formation size, and this view was taken by Upton (1923).[32] Three main considerations, however, oppose this view :

(1) It is not possible as atomisation proceeds to preserve the value of $(V_s-V_w)_c$ for each new globule formed from the parent globule and this imposes a limit on subdivision.

(2) Although physicists are not unanimous in their views concerning the nature of the variation of σ with *d* for very small values of *d*, there is a substantial body of opinion which considers that σ increases with decrease of *d* for very high curvature of the interfacial surface.

(3) The increasing slopes of the curves in the aerodynamic region (Fig. 7) accord with the dictates of common sense. An abrupt discontinuity as introduced by the region boundary is open to grave doubt.

Practical Points Arising

The following practical points emerge from the above academic inquiry :—

A badly designed mechanical moisture separator will collect the drops, but insight is needed to collect the liquid originally contained in droplets, and the latter will be the major part. The successful design of the separator depends upon its ability (*a*) to avoid the fracture of globules, (*b*) to encourage coalescence and in consequence enhance the likelihood of precipitation.

If fracture is to be avoided, the flow approaching the separator must be uniform and straight. It must not encounter any bends or area constrictions before or at the separator. If possible, the separator should be situated at the bottom of a vertical main in which the steam is descending as there is a tendency for the globules to slide towards the axis under the influence of the velocity gradient.

To encourage coalescence, the tortuous path should be of ample length to give time for meeting. The fluid velocity should be sufficiently high to carry small globules to the outer periphery, and drainage of precipitated liquid should be so arranged that drainage to an exposed edge and the possibility of re-entrainment are avoided.

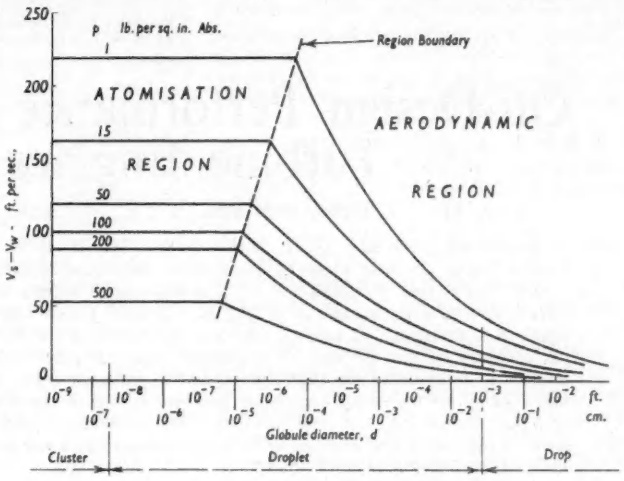

Fig. 7—Globule fracture curves

It remains to mention the erosion of l.p. blading in turbines. This subject has been closely studied by Gardner (1932),[33] who decided that the damage was done by "extremely small drops." He showed by velocity diagrams that for erosion to occur where it is actually found, it is necessary for the droplets to move at a small fraction of the steam speed. This combination of fine particles and low value of *f* appears at first sight to contradict the conclusions given above. The statements are, however, reconcilable when it is realised that a drop on being blown free from a stationary blade is immediately atomised, but lacks time to accelerate in the small gap separating the moving blades. It is seen from Fig. 7 that when $(V_s-V_w)=250$ft per second a drop can in theory be completely atomised even in a vacuum of 28in Hg.

Gardner invokes a theory of cavitation to explain the high surface pressures on the blades, but this is unnecessary. Small droplets are sufficiently rigid on account of surface tension to act as a solid abrasive, and the erosive effect is similar to that in a sand-blasting chamber.

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Off-Design Performance of Gas Turbine Engines

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In November, 1948, Mr. D. H. Mallinson and Mr. W. G. E. Lewis delivered a lecture before the Institution of Mechanical Engineers in London with the title "The Part - Load Performance of Various Gas Turbine Engine Schemes."[1] This report gave the results of a long investigation (in part of which the present writer was privileged to assist), and was the first ever to discuss the off-design performance of gas turbines in a general way. It may therefore be of some interest to re-examine the 1948 report, and to see what criticisms can be made in the light of the increased knowledge and experience in the design and operation of axial-flow compressors and turbines. The present note attempts a review of some of the points and gives as well a simple analysis of a matter which was treated rather briefly in the original report.

PERHAPS the most important result of the Mallinson-Lewis report was to show that among the vast number of possible permutations of the components of a gas turbine engine there are enough which can operate with stability and safety to produce practically any desired combination of relative power, revolutions per minute and efficiency.

It is also clear in retrospect that the report correctly assessed the relative merits of the various layouts for the many possible gas turbine applications of the future. As the authors foresaw, these conclusions are unaffected to any great extent by changes in the assumptions made about the performance of the separate components, for example, by improvements in compression efficiency or allowable turbine entry temperature.

The only important type of gas turbine cycle not mentioned was that with a large fraction of the air (more than 10 per cent, say) tapped off during the compression, and used as a source of compressed air instead of being passed through the combustion system and turbine. The chief application of this cycle at present is in a "by-pass" jet engine, where the secondary air is exhausted through a "cold" jet nozzle so as to improve the efficiency of propulsion of aircraft. However, this way of producing a large volume flow of air at a pressure of up to two atmospheres may be applied in many industrial fields, such as sewage disposal and ventilation.

The term "cross-compound schemes" was used to describe all those two-spool gas turbine engines in which the low-pressure compressor is driven by the high-pressure turbine, and vice versa. A good deal of effort was spent in classifying these schemes, and in calculating their performance, before it was fully realised that they are all inherently unstable when axial-flow or centrifugal flow compressors are used. The reason for this was briefly given on page 214 of the paper.[1] The cross-compound schemes are, in fact, only stable with positive displacement compressors (e.g. the Lysholm type), which are very rarely used in the larger sizes on account of their great cost and weight.

The careful tabulation of these useless schemes on page 202 was therefore of little value, particularly in view of the fact that it is not complete. The large number of two-spool arrangements that were arbitrarily omitted includes some—with compressor turbines in parallel—which would be fairly stable, though still not as desirable as any of the straight-compound schemes.

Intercooling. — The authors assumed throughout the calculations that when an intercooler is placed between the low and high-pressure compressors of a two-spool gas turbine engine it reduces the temperature of the partially compressed air to a fixed value, independent of the air mass flow or pressure. This assumption implies, of course, an effectively infinite mass flow of coolant. It was then explained (Fig. 25)[1] that the effect of such cooling on the performance of a gas turbine engine is to move the operating line on the low-pressure compressor diagram closer to the surge line. This tendency is, of course, undesirable, not to say dangerous, and severely reduces the attraction of the gain of power (per pound of air mass flow) due to the cooling.

However, it was pointed out at the time by the present writer that if the flow of coolant is controlled so as to make the thermal ratio (=actual temperature drop of the air/maximum possible temperature drop) increase at part load according to a rather simple law, the tendency to surging can not only be avoided, but actually reversed so as to prevent the possibility of surging altogether. The theory of this "variable cooling effect" was subsequently published.[2]

Now although in some engines the cooler could presumably be made extremely large, in many practical cases the allowable size is sufficiently small to falsify the assumption made by Mallinson and Lewis that the air is always reduced to the same temperature when passed through the intercooler. Rather, the cooler is most effective with a low air mass flow (i.e. at part load). Thus part of the improvement in stability described in the preceding paragraph is automatically (and perhaps unwittingly) achieved by designing for, and fitting, a small intercooler which gives a thermal ratio of only 50 per cent, say, at the design point. The ratio will then probably rise towards 90 per cent at low engine power. Such a feature does now exist on at least one gas turbine engine—in the two-stage high-pressure centrifugal compressor of the Rolls-Royce RM60 marine engine.[3]

Compressor Characteristics.—On page 199[1] it is stated that "A compressor for land installations, unhampered by weight restrictions, would probably, by the use of extra stages, be able to have a characteristic in which the region of nearly constant efficiency, and of ΔT_s varying with N^2, could be extended . . . to include the design point."

The belief is very widespread among non-aircraft engineers that in the design of a compressor (or for that matter of any other component) some efficiency and flexibility is willingly sacrificed in order to save weight. Indeed, this belief leads some designers to go to the opposite extreme, and equate weight and bulk with efficiency and safety. For example, the axial-flow compressor of the gas turbine engine installed in M.V. "Auris"[4] uses twenty-four stages to achieve a pressure ratio of less than four. Only eight or nine stages would be considered sufficient for a conservative and reliable aero-engine compressor.

However, the above belief is rarely justified, because for almost all aircraft duties it is more important to have a high engine efficiency than a high power-weight ratio (though, of course, both are important). Except perhaps for very short ranges the extra fuel that must be carried for an inefficient engine more than annuls any saving that might be made in the weight of the engine itself. And in fact, most aircraft gas turbine engines have compressors that are more efficient than those in marine and industrial engines, since they are more up-to-date and more carefully designed without regard to cost.

It is true that the use of very high gas Mach numbers in the early aircraft engine compressors impaired the efficiency and also narrowed the region of high efficiency on the pressure ratio/flow map, but such a compromise is rarely made to-day. Rather, a better knowledge of the design of blades enables high gas speeds to be used consistent with the highest possible efficiency. Also, the size of the region of high efficiency is greatest when the pressure ratio is small, which is one of the chief advantages of the two-spool type of engine, with its independent low pressure ratio compressors.

Similarly, the belief that an axial-flow compressor with a very large number of stages is somehow "safe" is only true in that the bending stresses on the blades due to the gas forces are low. So far as the aerodynamic operation goes, there is no improvement in the stability, the lack of which usually

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Appendix showing notation :

P, T—Total pressure and temperature at the several stations 1, 2, 3, 4.
r—Pressure ratio of the compressor $= P_2/P_1$.
θ—Temperature ratio of the compressor $= T_2/T_1$.
n—Polytropic exponent, defined by Equation (1).
a—A number, defined by Equation (5).
t—Ratio of turbine and compressor entry temperatures $= T_3/T_2$.
q—Mass flow coefficient $= Q\sqrt{T}/P$.
C_{pa}, C_{pt}—Mean specific heats of the air during compression and expansion.
N—Revolutions per minute of the rotor shaft.
f—A function of q_2, defined by Equation (3).
Stations 1 and 2 are at entry and exit of the compressor; stations 3 and 4 at entry and exit of the turbine.

causes fatigue and damage, any more than in the efficiency. The greatest stability is obtained, once again, by using low pressure ratios, as in the two-spool engine.

Finally, whether or not ΔT_c is proportional to N^2 depends chiefly on the pressure ratio of the compressor and the type of turbine driving it, and has nothing to do with the number of stages used to achieve any given pressure ratio, as will be shown later.

Turbine Characteristics.—Because the results of full-scale turbine test results were not available to the authors, an elaborate performance diagram was constructed from figures of loss and deflection interpolated from cascade tests, and this diagram was used throughout the investigation. The fact that both the pressure ratio and the temperature ratio (and hence the efficiency) of a high-speed turbine are often almost unique functions of the mass flow coefficient was also mentioned, and such "single-line" characteristics were drawn in Fig. 10 of that paper. However, the consequences of this fact are rather more important (especially in jet propulsion engines) than is indicated by the brief treatment given.

If two turbines with such unique characteristics are placed in series, whether or not they are on separate shafts, it follows that if the mass flow coefficient ($Q\sqrt{T}/P$) is held constant at any one section in the expansion the coefficients at all other sections upstream are uniquely determined, i.e. they are independent of the individual values of the mass flow, pressure or temperature. This effect is obtained when, for example, a choked propulsive nozzle is placed after the two turbines or if any section within the turbines is itself choked. This point was briefly mentioned in the paper on page 213.

In the case of a two-spool jet engine with two turbines in series on separate shafts the propulsive nozzle which follows is usually choked at mass flows near the design value, so that the temperature drop across each turbine is held constant. And if the value of $\Delta T/N^2$ is also nearly constant in each, as, for example, is assumed on page 200 of the report, it follows that the ratio of the two rotational frequencies is fixed. This is, of course, exactly what is not wanted in a two-spool engine, since the flexibility and efficiency lie wholly in the infinitely variable speed ratio between the two shafts. Fortunately, the difficulty does not hamper the operation in practice, for the region where flexibility is most necessary is in the acceleration from idling speeds, where neither the final nozzle nor any other section is choked, and the "locking" of the shafts does not occur (see inset to Fig. 26).[1] Also the assumption that $\Delta T/N^2$ is constant is a rather special one, as will be seen later.

The Relation Between Top Temperature and Revolutions Per Minute in a Gas Turbine Engine.

On page 198 of Ref. 1 it is stated that: "The possibility of good part-load efficiency for the desired working range, promised by any particular component arrangement, is of little value, however, if the arrangement encounters major practical difficulties in operating over this range. Mechanical problems excepted, these difficulties are: surging of the compressor or compressors; overheating of one or other of the turbines; overspeeding of one or other of the rotors. Of these, surging presents the most impassable limit, and it seems likely that this condition must be avoided at all costs."

In accordance with these introductory remarks, the investigation was concerned with the selection of gas turbine engine cycles primarily for efficiency and stability, although the variation of top temperature and revolutions per minute was also indicated in some cases.

Since 1948 more experience has been acquired in preventing engines from running into compressor surge, and indeed in understanding the mechanism of surging itself. But if control over the other two difficulties—overheating and overspeeding—is found to be necessary, it is usually left to governing devices which override the manual throttle and prevent disaster. No extension of the work concerned in this paper seems to have been published, in the direction of choosing the design parameters of a new engine project not only for efficiency and stability, but also to lessen or eliminate the need for speed governing or temperature controls.

However, many designers have used, in a qualitative fashion, the reasoning set out in the following approximate analysis. This shows that it is possible to predict—at any rate roughly—how the revolutions per minute is related to the entry temperatures to the compressor and turbine, and to the compression ratio, for a single-shaft compressor driven by a turbine. (Whatever excess power is in the gas leaving the turbine does not enter the analysis.) As in the previous section, it is assumed that the pressure and temperature ratios across the turbine are unique functions of the mass flow coefficient ($Q\sqrt{T}/P$). If this simplifying assumption is not made the analysis can only be carried out by considering a particular design of compressor and turbine, as was done in Ref. 1, and the work becomes much more complicated.

The relation between the pressure ratio r and the temperature ratio θ of a compressor may be written as

$$r=\theta^{n/(n-1)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where n is a number a little larger than 1·40, which value it approaches as the efficiency of the compression becomes more nearly perfect. In differential form, equation (1) is

$$\frac{dr}{r}=\frac{n}{n-1}\cdot\frac{d\theta}{\theta} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Since the turbine just drives the compressor, the work done on and by the air is equal (neglecting the mechanical friction of the shaft). Therefore, with the usual notation, (which is set out in the Appendix),

$$C_{pt}(T_3-T_4)=C_{pc}(T_2-T_1)$$
$$=C_{pc}T_1(\theta-1)$$

and

$$t=T_3/T_1=\frac{C_{pc}}{C_{pt}}\cdot\frac{(\theta-1)}{1-(T_4/T_3)}.$$

But (T_4/T_3) is assumed to be a unique function of $q_3(=Q_3\sqrt{T_3}/P_3)$, so that we may write

$$\frac{1}{1-(T_4/T_3)}=f(q_3) \quad . \quad . \quad . \quad (3)$$

Therefore

$$t\propto(\theta-1)\,.\,f(q_3)$$

and

$$\frac{dt}{t}=\frac{d\theta}{\theta-1}+\frac{df}{f} \quad . \quad . \quad . \quad . \quad (4)$$

If, now, by definition

$$a=\frac{n}{n-1}\cdot\frac{\theta-1}{\theta} \quad . \quad . \quad . \quad (5)$$

Equations (2), (4) and (5) give

$$\frac{dt}{t}=\frac{dr}{ar}+\frac{df}{f} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Furthermore, since $Q_3=Q_1$, and $P_3\propto P_2$, it follows that

$$\sqrt{t}\propto q_3 r/q_1,$$

and therefore

$$\tfrac{1}{2}\cdot\frac{dt}{t}=\frac{dq_3}{q_3}+\frac{dr}{r}-\frac{dq_1}{q_1} \quad . \quad . \quad . \quad (7)$$

Finally, the revolutions per minute is introduced by making the common assumption that over the region of interest

$$q_1\propto N/\sqrt{T_1},$$

so that

$$\frac{dq_1}{q_1}=\frac{dN}{N}-\tfrac{1}{2}\cdot\frac{dT_1}{T_1} \quad . \quad . \quad . \quad (8)$$

It follows from the elimination of r and q_1 between equations (6), (7) and (8) that

$$\frac{dN}{N}+(a-1)\cdot\frac{dT_1}{T_1}-(a-\tfrac{1}{2})\cdot\frac{dT_3}{T_3}-\frac{dq_3}{q_3}+a\cdot\frac{df}{f}=0$$
$$. \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Note that if the turbine is choked, or is followed by a choked section such as a propulsive nozzle, q_3 is held constant, and the last two terms in equation (9) become zero.

It is clear from equation (9) that N is independent of T_3 when $a=\frac{1}{2}$. Now a typical value of n is 1·50, which gives, from equations (1) and (5)

$$r=\left(\frac{3}{3-a}\right)^3 \quad . \quad . \quad . \quad . \quad (10)$$

So in this case the condition that $a=\frac{1}{2}$ corresponds to the very low compression ratio of $r=1\cdot73$.

It also follows from equation (9) that if $a=1$ (which corresponds to a compression ratio $r=3\cdot39$ if equation (10) is used), then the revolutions per minute N is independent of T_1 and proportional to $\sqrt{T_3}$. This implies, putting f constant in equation (4),

$$\Delta T_c=(T_2-T_1)\propto N^2$$

Thus it is only when the compression ratio of a compressor-turbine set is between three and four, say, and the turbine is choked, that the values of $\Delta T/N^2$ for the compressor and turbine can be considered constant; and the supposition implied[1] that $\Delta T/N^2$=constant applies to the running line of all well-designed components is not justified. Actually the above conditions were satisfied in most of the early jet engines, with centrifugal compressors, but to-day the range of pressure ratios is much greater and three deductions from equation (9) are of practical importance:

(*a*) In a single-shaft engine with a pressure ratio greater than about four (i.e. with a greater than one), operation with a higher intake temperature than the design value—e.g. for a jet engine at high speed and low altitude—must be accompanied by a reduction of either T_3 or N below the maximum values allowed under design conditions. Otherwise the other parameter will exceed the design value—that is, the engine will either overheat or overspeed.

(*b*) With an intake temperature lower than the design value, for example, during flight at high altitude, the reverse effect occurs, and if the engine is run at the design revolutions per minute the top temperature (and hence the power output) falls. Therefore it is desirable to design the rotating components to allow considerable overspeed at low intake temperatures, if the maximum power is required.

(*c*) In a two-spool engine, where the high-pressure compressor has a pressure ratio of the order three or four, neither the top temperature nor the revolutions per minute of the high-pressure shaft depend on the conditions in the low-pressure compressor. Therefore the overspeed mentioned in (*a*) when the intake temperature is low is confined to the low-pressure shaft, and there is no danger of overheating.

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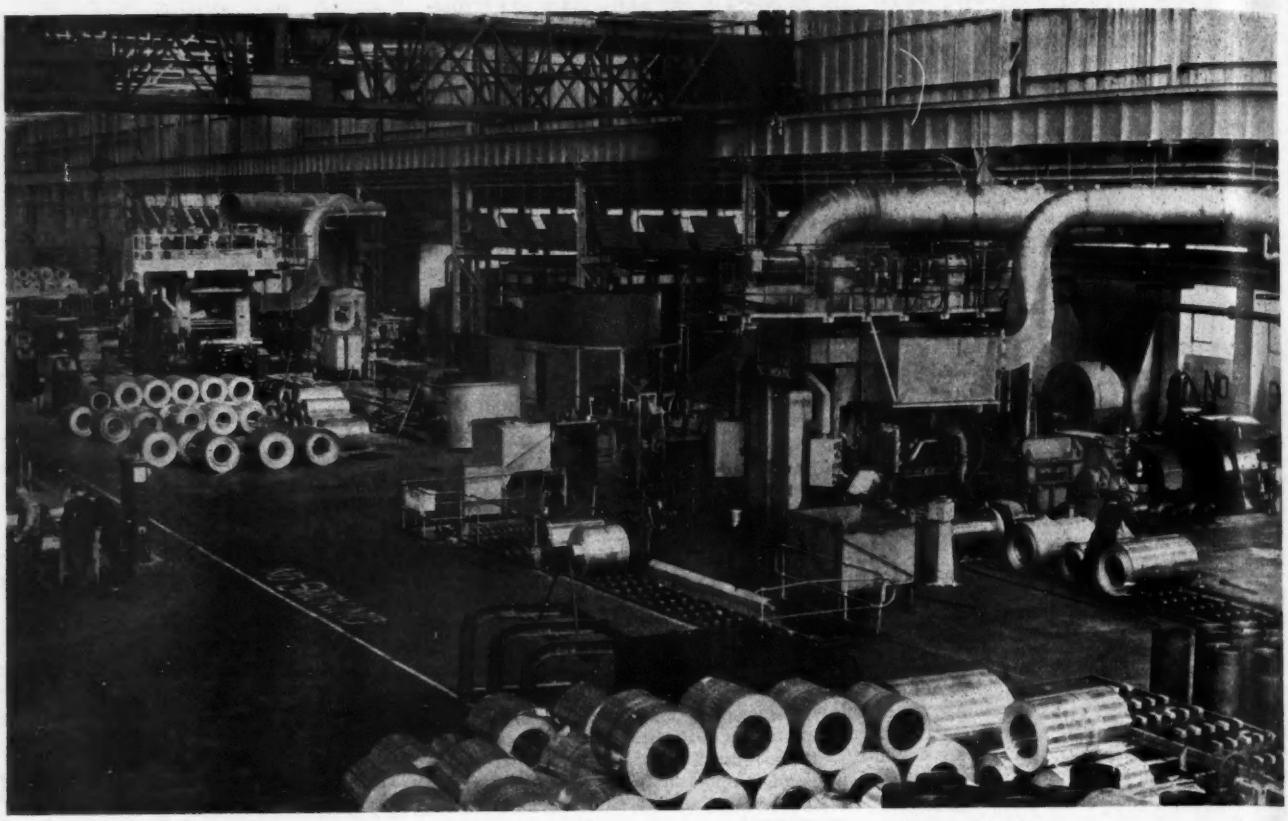


Part of the cold mill showing the two 17in and 42in by 60in four-high non-reversing cold strip mills

"Stamco" shearing line in the foreground with the flash annealing furnace in the background

Aluminium Strip, Sheet and Plate Mill at Resolven

No. II—COLD MILLS AND FINISHING LINES

(*Concluded from page 49, July 9th*)

At Resolven, in a valley a few miles inland from Neath in South Wales, a new mill for the rolling of strip, sheet and plate is nearing completion and is already in partial production. When it is in full operation, the new plant, which has been built for the South Wales Aluminium Company, Ltd., a member of the Tube Investments group, will produce a variety of aluminium alloys ranging from commercial purity aluminium to high-strength heat-treated alloys in the form of circles, flat sheet, coiled sheet and corrugated.

COILS from the tandem mill can be transported to three annealing furnaces (illustrated on page 82), which, complete with up-ending machine, loading crane and furnace charger, have been supplied by Stordy Engineering, Ltd. The furnaces, which each have a floor space measuring 18ft by 8ft, differ from the orthodox electric furnace in that they are entirely air circulated, the heater batteries being remote from the working chamber; thus radiation effects are eliminated. Each furnace is designed for an output of 2 tons per hour of coiled strip up to 550 deg. Cent. The rating is 640kW, but the heater battery, which can be removed as a unit, is subdivided to give 140kW, 215kW and 280kW and any combination of such ratings. Air is circulated by two high-temperature centrifugal fans, each of 15,000 cubic feet per minute capacity, which maintain low temperature heads and provide an adequate distribution of turbulence throughout the working space. Fabricated ductwork in heat-resisting steel supplies and recirculates the air and damper adjustment gives a true balance of heat distribution.

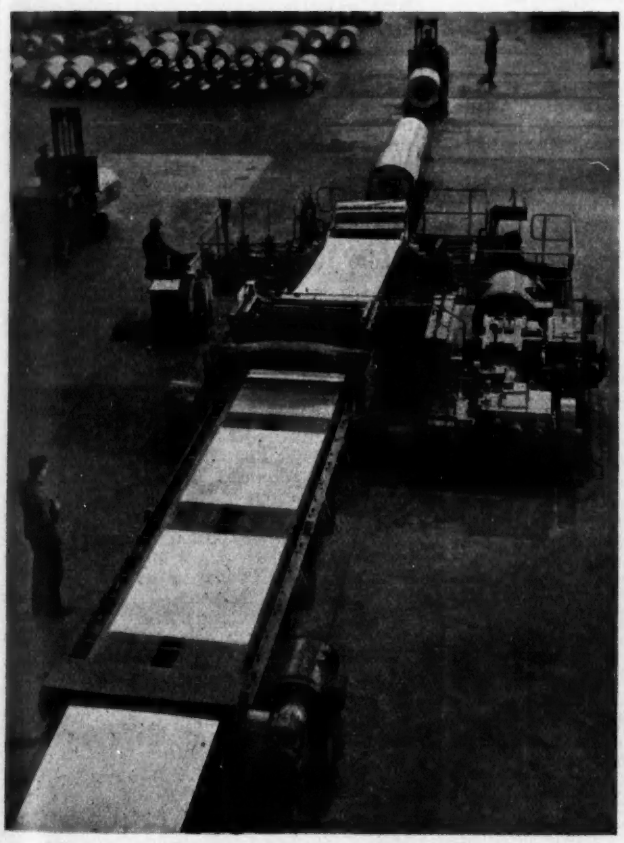
From the loading point the coils are fed by gravity conveyors to an up-ending machine and placed on the loading stillage by a mast crane, the loading pattern being arranged to give maximum load density. A charging machine, having six expanding charging forks, picks up this load, amounting to 16 tons of hard coils, and traverses on rails spaced at 22ft centres across the front of the furnaces and loads the furnace. After annealing the hot load is placed on a cooling stand adjacent to each furnace and from there the process is reversed and the annealed coils are returned to the unloading stillage.

Fork lift trucks convey the coils to the Robertson 17in and 42in by 60in, four-high, non-reversing cold reduction mill. This mill can reduce strip 50in wide by 0·25in thick to 0·012in thick, in coils weighing 3000 lb at rolling speeds of 0/1000ft per minute and is powered by a 1500 h.p. motor running at 0/500 r.p.m. and driving through Wellman Bibby couplings and a single-reduction, double-helical gear unit manufactured by Turbine Gears, Ltd. The motor is supplied from two English Electric 700kW generators. The work rolls are of chrome alloy forged steel of 95 deg. Shore hardness, while the cast steel back-up rolls are of 50/55 deg. Shore hardness and have flood-lubricated support bearings. The rolls are hydraulically balanced and the arrangements concerning the screw down gear, the withdrawal of rolls, &c., are generally the same as for the tandem mill. There is a second four-high, non-reversing cold mill, which has been reconstructed by W. H. A. Robertson and Co., Ltd. Both the four-high cold mills are shown in our first illustration opposite.

By means of slat and gravity roller conveyors the coils arrive at the tailing drum where a tail is formed before moving on to a power-operated slat-feed conveyor to the 16in diameter cone decoiler. This can take a 34in diameter coil and is expanded by two hydraulic cylinders. Back tension is supplied by a generator of 50kW at 0/1200 r.p.m., driving through single-reduction double-helical gears to give the decoiler speeds of 0/997ft per minute. There is a sticker pattern bridle having three upper and four lower steel rolls, the vertical movement of which is hydraulically controlled, and a hydraulically controlled motion feeds the leading edge of the strip into the mill. The 16in diameter drum coiler, which is similar to that fitted at the tandem mill, and can accommodate a 34in diameter coil, is driven by a 300 h.p. double-armature motor running at 0/1200 r.p.m. and driving through double-helical reduction gearing to reduce the speeds to 0/248 r.p.m. and give coiling speeds of 0/1038ft per minute. An air brake acting on the drum assists collapse and expansion.

A portable bridge piece connects with a 6in roll coiler capable of taking a 40in diameter coil and having a coiling speed of 0/1144ft per minute when driven at 0/729 r.p.m. through single-reduction gearing by a 75 h.p. motor running at 0/1375 r.p.m. The tailing and coil ejecting mechanism is pneumatically controlled and the coils move by gravity conveyor to a weighbridge and tippler and then by a power operated slat conveyor to a point ready for the next operation.

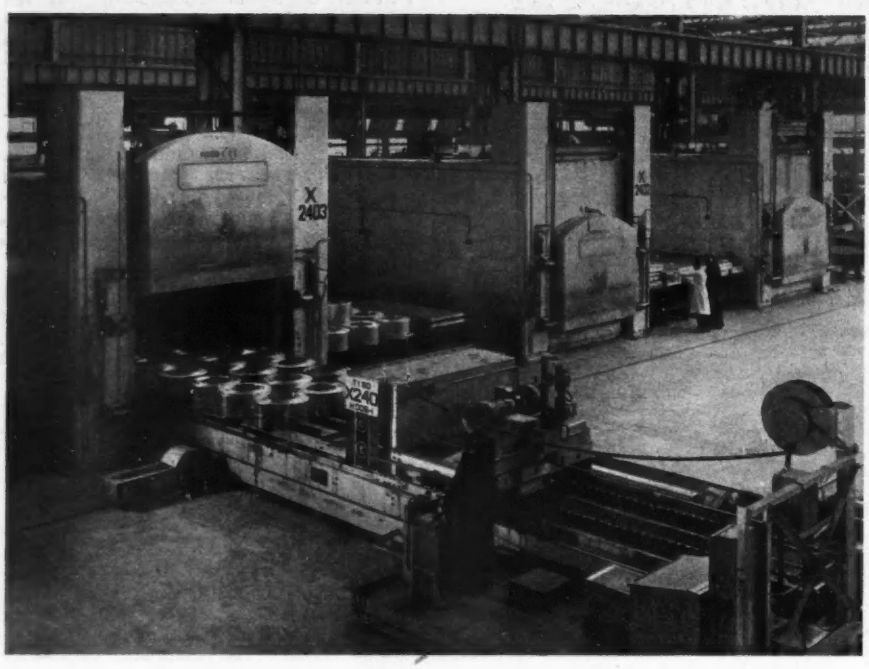
Some of the material from the four-high mill passes to a 18in by 48in, two-high, non-reversing cold mill, manufactured by W. H. A. Robertson and Co., Ltd.; it is designed to reduce soft aluminium alloy strip, 38in wide, from 1mm to 0·45mm thick. The maximum permissible



A cutting-up line showing a decoiler feeding into a roller levelling machine working in conjunction with an automatic shear

Rotary corrugating machine of multi-roll design

width of strip is 42in and the minimum 24in, while the maximum thickness at entry is 1mm and minimum thickness after rolling is 0·3mm. Power is provided by a 500 h.p. d.c. motor running at 0/1100 r.p.m. and driving through a coupling and single-reduction gearing to give roll speeds of 0/255 r.p.m. and rolling speeds of 0/1200ft per minute. Power for the mill is supplied by a motor generator set consisting of a 650 h.p., 1·0 power factor, 1000 r.p.m. synchronous motor, a 405kW generator and two 53kW, screen-protected reel generators. All the



The battery of air circulated annealing furnaces, each of 2 tons per hour capacity, and the furnace charger which takes a load of 16 tons

electrical plant was provided by the British Thomson-Houston Company, Ltd. The rolls are hydraulically adjusted by hydraulic cylinders under the bottom roll chocks.

The 16in diameter cone decoiler is linked with a 45kW drag generator, running at 0/1200 r.p.m., which drives through gear units at each side of the decoiler and hydraulic jacks raise the coil to the correct height to allow the headstocks to be traversed. The strip is fed into the mill by a hand-operated wiper press. After leaving the mill rolls the strip is led over a pass-line roller to the 16in diameter drum coiler, fitted with a belt blocker and powered by a 60 h.p. 0/1200 r.p.m. motor driving through single-reduction, double-helical gear to give a drum speed of 0/289 r.p.m. Coil ejector arrangements are as for the tandem mill.

An oil cleaning plant is installed to serve the two four-high, 17in by 42in by 60in non-reversing mills. The oil is fed to the mills by Harland "Duoglide" pumps, each having a capacity of 400 gallons per minute against a 175ft head. Afterwards the oil drains to a sump from where it is delivered by Harland "Monoglide" pumps, each capable of delivering 450 gallons per minute against a head of 96ft, to a battery of "Lolos" twin cartridge strainers, each of 3000 gallons per minute capacity. From the strainers the oil is piped to a strained oil tank and then passed to a group of Stellar filters, each having a capacity of 50 gallons per minute, which are associated with a Stellar jet "Filtraider," a bed-forming tank and a Girdlestone filter bed-forming pump of 150 gallons per minute capacity against a 30ft head. After being filtered the oil passes to the filtered oil tank ready for recirculation. An almost similar arrangement of oil cleaning plant serves the two-high, 18in by 48in mill.

Depending upon the form of the end product, strip from the four-high and two-high mills is delivered by fork lift truck to a decoiling, edge trimming, slitting and recoiling line, supplied by the Loewy Engineering Company, Ltd., which is suitable for operating at speeds between 200ft and 500ft per minute to reduce 52in wide strip having a maximum thickness of 0·064in down to 0·01in. This cold slitting line is driven by Vickers V.S.G. hydraulic pumps and motors, while a special control equipment maintains a maximum line tension of 5000 lb. The edge trimmer and slitter is of mandrel pattern with loose slitting arbors and is complete with rotary guillotine scrap cutter and conveyor. The coilers have independent drives and belt wrappers are provided for the 8in diameter drums.

Two cutting-up lines, one of which we illustrate, have been installed in the mill and two Hallden flying shear machines supplied by W. H. A. Robertson and Co., Ltd. form part of the equipment. One line is suitable for dealing with strip up to 48in wide in thicknesses from 0·008in to 0·060in to produce sheet in lengths ranging from 12in to 12ft, and the second line is for use with strip up to 54in wide, ranging in thickness from 0·028in to 0·125in to produce sheet sheared to lengths ranging from 30in to 20ft. Both units have a strip speed of between 100ft to 300ft per minute.

The coils are delivered to the cutting-up lines by a fork lift truck and move via a gravity roller conveyor to a turntable and so to a cone decoiler (which can take coils of 34in outside diameter and weighing a maximum of 1·25 tons) provided with a hydraulically-operated jack and cone adjustment arrangements. The material is flattened and sheared to length in the machines, each of which consists of a stand of flattening and feed rolls and a rocker guillotine shear. The leveller rolls, ten in number, are of carbon chrome alloy steel to 85/90 deg. Shore hardness and are positively driven through totally enclosed spur gearing. Variation in length is obtained by relating the number of reciprocations per minute, made by the shear, with the linear speed of the strip.

A belt conveyor transfers the sheets to a stacking frame which, in the 54in line, can be removed and replaced by a portable belt conveyor to allow the sheet to pass, as required, to a rotary corrugating machine which has been built to the designs of the South Wales Aluminium Company's own engineering staff and is illustrated on page 81. It is of multi-roll pattern, and can be adjusted to produce twelve corrugations of ¼in or ⅜in at 2½in pitch or ten corrugations at 3in pitch in sheet up to 20ft in length and ranging in thickness from 18 to 27 S.W.G. Sheet material from both cutting up lines can also be forwarded to a stamp corrugating machine.

Some material is forwarded to the Yoder machine, which will take coils up to 1500 lb in weight by 24in wide by 8in, 10in or 16in inside diameter, and slit them into strips having a minimum width of 2½in. The machine consists of a cone decoiler, a pull pattern gang slitter having 4in diameter top and bottom arbors, solid ring cutters with adjustable spacing, rotary scrap choppers and also pull-pattern manually collapsible recoiler drums of 8in, 10in or 16in diameter.

For the accurate side and end trimming of sheets which have been roller or stretcher levelled the Head Wrightson Machine Company, Ltd., has supplied a "Stamco" fully automatic shearing line, which consists of four guillotine shears, two for side and two for end trimming, which can be adjusted, within the limits of the machine, to suit the length and width required.

In addition to supplying the annealing furnaces, Stordy Engineering, Ltd., has provided a flash annealing furnace for the rapid annealing of sheets and circles. The furnace, which can handle sheets up to 6ft wide and circles down to 5in diameter, at a rate of 2 tons per hour, is electrically heated and two centrifugal high-pressure fans supply air through heater batteries and circulate it through ducting. Precise control is exercised over the distribution of the air and uniform temperature conditions achieved. The loading conveyor consists of a series of non-metallic ropes, which deliver the work to the furnace conveyor, which consists of strips of tensioned heat-resisting material, and both conveyors are designed to handle work without abrasion to polished surfaces. After passing through the furnace the work enters the cooling section, where cold air is directed on to it from ducts. The lower illustration on page 80 shows the "Stamco" line and the flash annealing furnace.

The electricity supply is taken from the grid and transformed down to 6600V by two 15,000kVA transformers, while the supply is controlled by a remote operated switchboard consisting of two 1600A incoming and three 800A outgoing circuit breakers, the equipment being supplied by the English Electric Company, Ltd. This company also provided the three 1000kVA and two 750kVA transformers for the low-tension a.c. power. Metropolitan-Vickers Electrical Company, Ltd., has supplied the two 750kVA transformers in the foundry, the Break A.I.R. switchboard, and the 750kW mercury arc rectifier for supplying direct current to the cranes and motors on the process lines.

Idle Industrial Capacity in India

OUR Indian Correspondent states that a comparative analysis of over 150 industries in India during the past three years reveals a trend towards substantial increases in installed capacity accompanied by a disturbing fall in production levels in many instances. Although the general index of industrial production rose from 117·2 in 1951 to 128·7 in 1952 and about 134 in 1953, output in a number of specific industries has declined. Even in those industries in which production has been rising, a large proportion of installed capacity is not being utilised. A study of official figures just released by the Government points to a specially heavy incidence of idle capacity in the engineering and heavy chemical industries. In many cases unused capacity exceeds 50 per cent, and relatively very few industries are working at even 75 per cent of their installed capacity.

Last year the Government appointed a committee to look into the matter of idle capacity in the engineering industry. The committee has submitted its report and has suggested ways of using this capacity and recommends new lines of production for items for which the country is still dependent on imports. The report proves that there is enough engineering capacity for most of the essential products, and it is considered likely that the whole import policy will have to be revised soon to encourage and protect the indigenous industry.

Battle of the Boilers

By ENGINEER REAR ADMIRAL SCOTT HILL, C.B.E., M.I.Mech.E.

No. I

The Battle of the Boilers took place as the nineteenth century ended and the twentieth century began; and as the Navy changed over from Scotch boilers to water-tube boilers. Were water-tube boilers to be adopted at all? If so, which boiler was to be adopted, the Belleville, the Yarrow, the Thornycroft or the Babcock? The story has been recorded before. The interest of this account lies in the fact that the author served in ships with Belleville boilers, just those boilers that, having been adopted by the Admiralty, were subjected to heavy criticism and which were subsequently rejected. His contention seems to be that the adverse criticism was not justified, that the boilers were ill-used and that they got a bad name because the ships in which they were installed suffered from other troubles having nothing to do with the boilers.

IN the last years of the nineteenth and the earlier years of the twentieth century—1894 to 1903—the so-called Battle of the Boilers raged with varying intensity in marine engineering circles, in technical papers, and, owing to the vigour of some of the protagonists—notably William Allan, M.P. for Gateshead—in the daily press.

Towards the end of that century it had become increasingly evident that, if warships were to carry more and heavier armour and armament, the most obvious action would be to reduce the great weight of water carried in the cylindrical boilers, with other reductions in the weight and space taken up by the propelling machinery. Inventors of the maritime nations were advocating a complete departure from the old and tried "Scotch" boiler and offering steam producers wherein the water was carried in tubes heated externally by the furnace and capable of standing higher pressures.

The Admiralty studied the problem and the candidates considered for adoption included the Belleville—a large tube boiler—the Yarrow, Thornycroft, Normand, Reed and other small tube boilers, and the Niclausse—which had large tubes with internal small tubes. The Belleville appealed particularly on account of its apparent sturdiness and because it was already in successful use in the Messageries Maritimes. In addition it required no access space at sides or back beyond that taken up by casings, mud drums and firing space. More room was thus available for fire grate area than any other boiler then known could provide, while the elements of which it was mainly composed could be removed through ordinary hatches, making the large openings then usual in the armour deck unnecessary. These advantages naturally appealed to the Director of Naval Construction.

An engineer officer—Edouard Gaudin—a native of Jersey, and easily mistaken for a Frenchman, was sent on a voyage of investigation in one of the Messageries Maritimes ships. His report, coupled with the fact that S.S. "Laos," of that line, had given three years' continuous service without important overhaul, determined the Admiralty—Sir John Durston was then the Engineer-in-Chief—to decide on this boiler for all the capital ships then about to be built.

Accordingly, the gunboat "Sharpshooter" had her existing boilers replaced by Belleville boilers and encouraging trials were carried out. Her new fuel consumption was found to be 1·8 lb per indicated horsepower, then quite a good figure. The large cruisers "Powerful" and "Terrible," each with forty-eight Belleville boilers, were next put in hand, and during the following years several classes of battleships and cruisers were laid down, as shown in the table.

During the same period steam pressures were raised to 350 lb in some ships and to 300 lb in others. Piston speeds were also increased. These changes introduced new difficulties with steam joints and new problems with the white metal bearings. Other changes were also made and, unfortunately, as the direct consequence, too much space was surrendered in certain ships to the Director of Naval Construction, so that access to the auxiliary machinery was cramped, which made repair and attention difficult. Engine-room temperatures became very trying to watch-keepers and, all-in-all, some of these ships became decidedly unpopular with engine-room hands. The larger cruisers were all "four-funnel" ships. This feature carried much prestige. In China especially, a "four-piecey funnel" ship was looked on with great respect. Nor was the four-funnelled ship without its prestige value on the high seas generally.

This very extensive, not to say overwhelming, order for new ships and, particularly, novel boilers, during the late "nineties" distributed in a comparatively short time amongst dockyards and contractors led inevitably to a variety of troubles. It soon became evident that there had been insufficient "briefing" either of the builders, the engineer overseers, or of the men who were to take charge of the ships in service. Small differences crept in, or were permitted, and unfortunate departures from experienced French practice were made. To-day so important a development would undoubtedly be accompanied by a "Belleville Handbook" and instructional courses would be arranged for officers and men. Had this been done the subsequent story might have been very different. But it was not, even though the possibility of trouble was foreseen. Brassey, of 1896, for example, while commending the Admiralty for its courage in going ahead and not waiting for the Merchant Navy to try out water-tube boilers first, at the same time foresaw considerable teething troubles and expressed doubt as to whether Belleville boilers could be forced.

Apart from the boilers the turbine was coming to the fore in 1898, and there were rumours of liquid fuel as Russia was already trying it out in the Belleville-boilered ship "Russia." So the Admiralty had plenty of calls on its attention.

As the new ships with water-tube boilers came into service several experienced something a good deal worse than mere teething troubles. There were really serious breakdowns. These breakdowns were by no means always due to the boilers. But a good deal of mud stuck to the latter. Conspicuous amongst the failures was the breakdown of "Hermes," involving her return home after only a year in commission; and there was also the extravagant fuel consumption of

TABLE—*Classes of Battleships and Cruisers fitted with Belleville Boilers*

Type	Class	Dates of laying down		Number in class	Number with Belleville boilers	Number of boilers per ship
		First	Last			
Protected cruiser	"Powerful"	1894	1894	2	2	48
Cruiser	"Arrogant"	1895	1896	4	4	18
Cruiser	Early "Diadem"	1895	1896	4	4	30
Cruiser	Later "Diadem"	1896	1897	4	4	30
Cruiser	"High Flyer"	1897	1897	3	2	—
Armoured cruiser	"Cressy"	1898	1899	6	6	30
Armoured cruiser	"Drake"*	1899	1899	4	4	43
Armoured cruiser	"Monmouth"	1900	1902	10	7	—
Battleship	"Canopus"	1896	1897	6	6	20
Battleship	"Formidable"	1898	1898	3	3	20
Battleship	"London"	1898	1899	3	3	20
Battleship	"Duncan"	1899	1900	6	6	24
Battleship	"Queen"	1901	1902	2	1	20

* "Good Hope" was another ship in this class

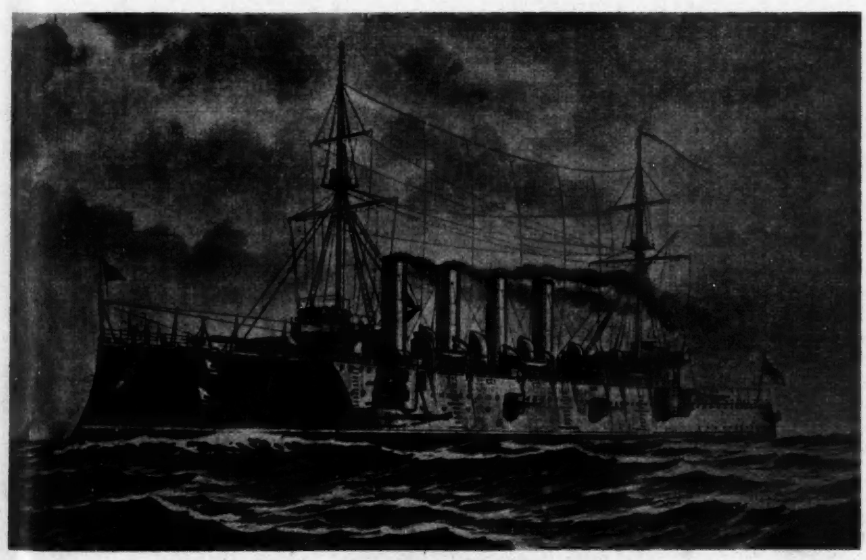


Fig. 1—H.M.S. First-class cruiser "Spartiate," 1898

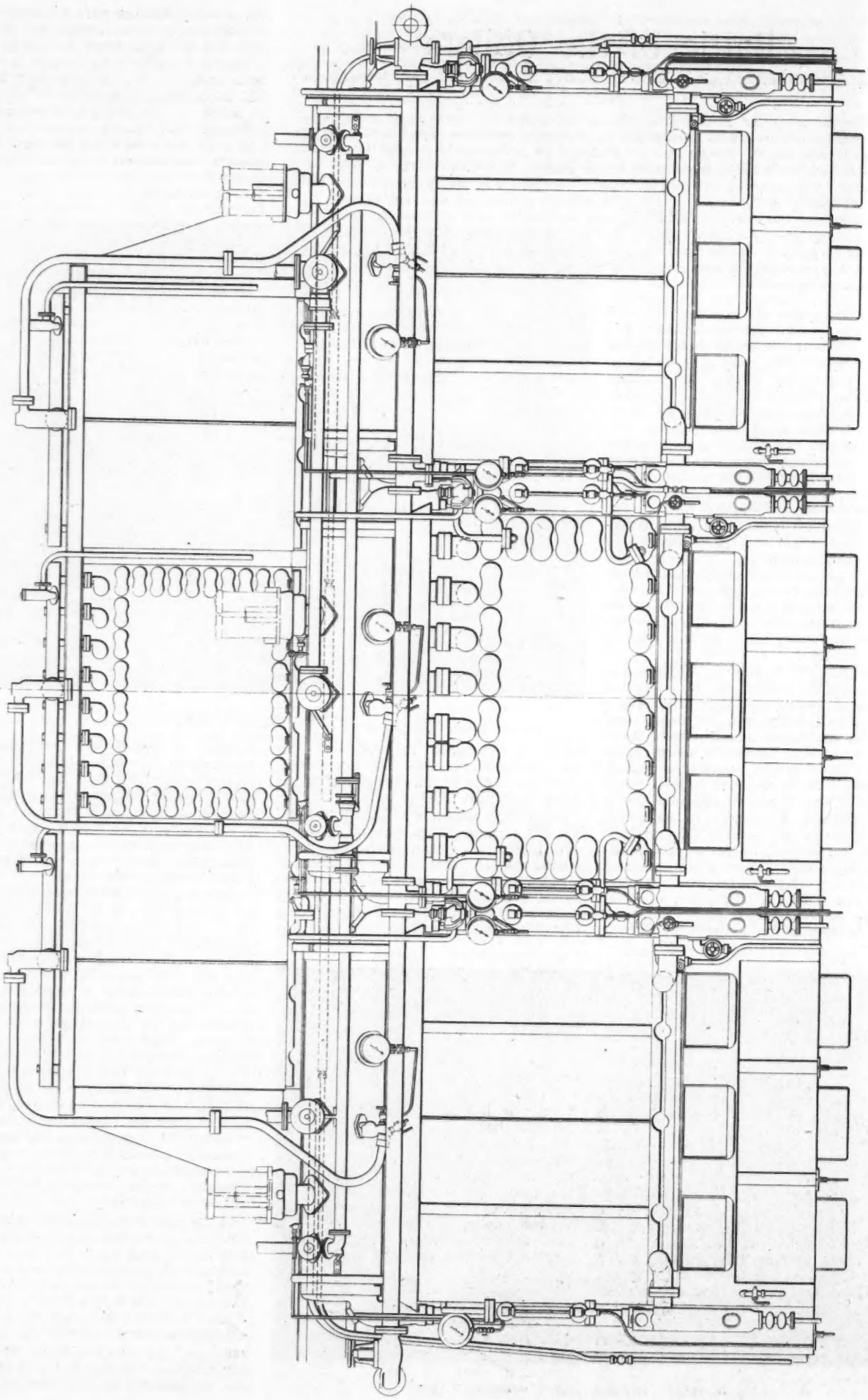


Fig. 2—Belleville boilers of H.M.S. "Spartiate"—forward group

"Europa" on passage from Portsmouth to Sydney. It took eighty-eight days, of which fifty-eight were under steam and the remainder coaling; and consumption worked out at 5 lb per indicated horsepower! That high rate of consumption was, in fact, largely a consequence of leaky condensers, leaky joints and a consequent high fuel expenditure in distilling. But it was the reputation of the boilers that chiefly and unjustly suffered.

cised for its policy. This journal, for example, gave a great deal of space to the question, and was highly critical of the departure in boiler practice. In July, 1900, it did not hesitate to write of "the failure of a great experiment," and it joined in the appeal for a "Committee of Enquiry." Comment elsewhere after a paper had been read by Sir John Durston before the Institution of Civil Engineers was, "that he had

under the chairmanship of Admiral Sir Compton Domville to inquire into the question of water-tube boilers for H.M. ships. All the members of the committee were connected with the Merchant Navy or Lloyd's, except Chief Inspector of Machinery, J. A. Smith. Interim reports appeared in 1901 and 1902, and a final one in 1904. The very first report recommended the abandonment of the Belleville boiler except in ships

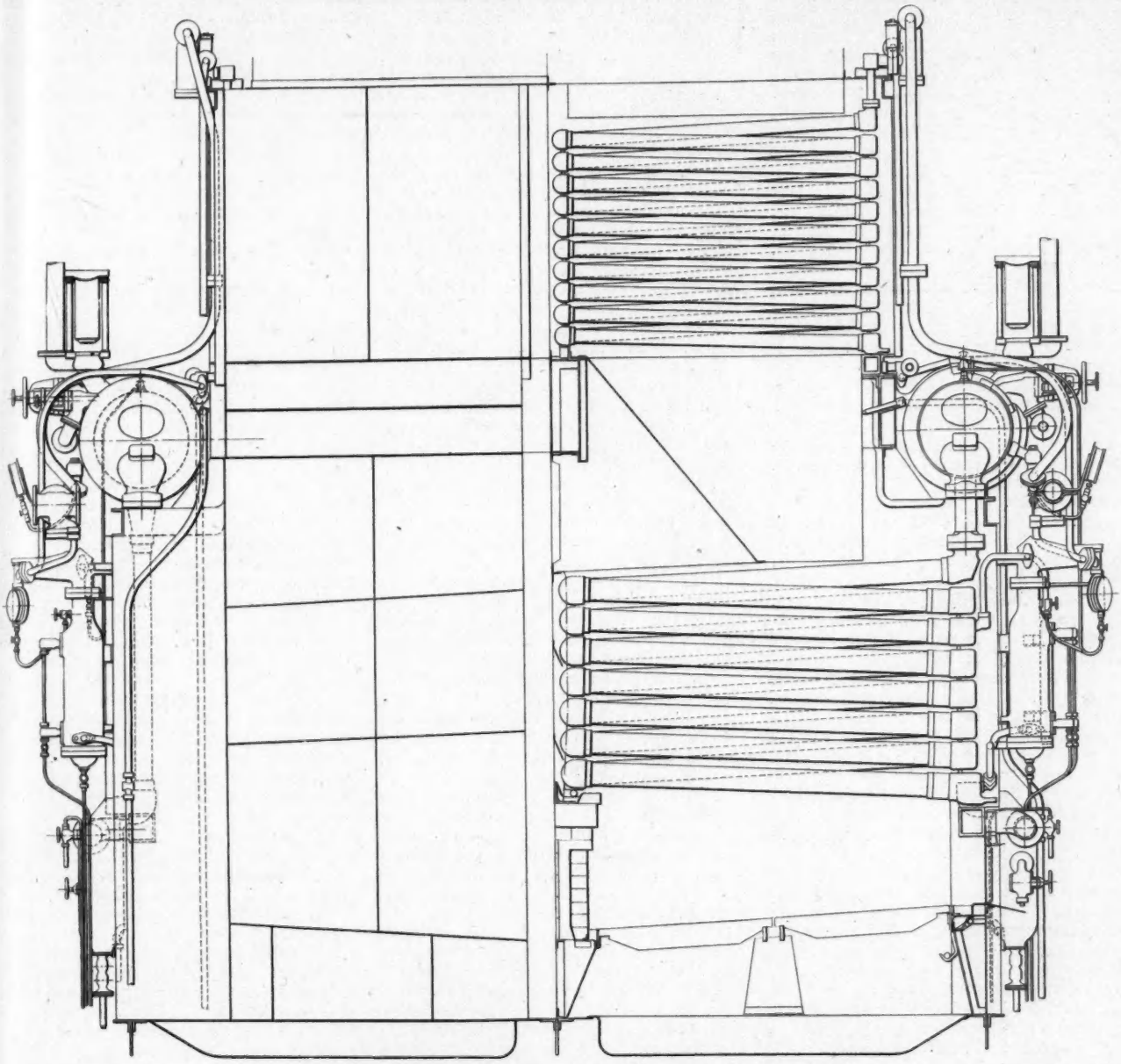


Fig. 3—Belleville boilers of H.M.S. "Spartiate"—forward group, end view

In 1896 "Powerful" ran successful trials and her sister "Terrible" did well in the Boer War. But both ships experienced troubles due to cramped machinery space and excessive engine-room temperatures. "Powerful" continued in sea-going service until 1912. "Terrible," having made one trip to China at 11·8 knots in 1902, burning 200 tons of coal a day, made another in 1904 at 12·6 knots, burning only 100 tons a day, indicating more competent handling and understanding, and disproving the idea, then very current, of rapid deterioration of the boilers.

By 1900 there were already a million indicated horsepower of naval machinery dependent on Belleville boilers. But the Admiralty was by then being heavily criti-

driven the last nail in the coffin of the Belleville boiler." Another engineer said that the Belleville was probably the worst boiler in existence! The boilers of "Powerful" and "Terrible" were retubed at about this time with solid-drawn tubes—a first fitting in later ships. There was an immediate renewed outcry, as these tubes had to be obtained from Sweden. British makers could not produce the right steel. Simultaneously attention was called to the fact that Russia, Holland, Portugal, and Elswick were trying the Yarrow boiler, and U.S.A.—very tentatively—the Babcock.

Sir Wm. Allan, M.P., was conspicuous in his attacks in the House and elsewhere. In September, 1900, the Admiralty yielded to the clamour and appointed a committee

already too far committed, and the fitting of Yarrow or Babcock boilers in future capital ships. The report was unanimous, except for some soft-pedalling by J. A. Smith. It is of interest to note that the committee also recommended the fitting of a mixture of cylindrical and water-tube boilers. This recommendation was adopted to some extent, but was recognised later to be a great mistake.

Despite the recommendations of the first report, Sir Wm. Allan kept up his attacks. So convinced was he of the demerits of Belleville boilers that in 1903, on hearing of proposed trial runs of "Spartiate"—Fig. 1—and "Europa" to Hong Kong and back, he offered 2 to 1 against the former and 10 to 1 against the latter completing the trials—a bet

he would have lost. The final report of the committee, dated June 12th, 1904, was sent to Admiral Domville for signature. By then the "battle" was dying down. He was flying his flag in the Belleville-boilered battleship "Bulwark." In his covering letter he wrote :—

"My experience with the Belleville boilers on the Mediterranean station has been very favourable to them as steam generators, and it is clear to me that the earlier boilers of this description were badly made and badly used. We have had no serious boiler defect in any of the ships out here, and the fact that two ships are about to be recommissioned with only the ordinary repairs undertaken shows that their life is not so short as I originally supposed. However, the second commission of these ships will be a very good test of the staying power of their boilers."

But breakdowns and delays had made, by that time, too strong a case against the boilers, even though many of the troubles experienced had nothing to do with them. For example, "Hermes" had to come home after one year in commission on the North American station ; "Spartiate" broke down badly on her first effort at acceptance trials—entirely due to condenser leakage and bearing troubles—and "Good Hope" never ran for any length of time at her higher revolutions until all her main bearings had been remetalled by Portsmouth Dockyard. The fact was that the ships then building embodied many new departures and advances. But the dog that got the bad name was the Belleville boiler.

Guerilla warfare and sniping against the Belleville boiler continued for many years, but the "battle," in fact, ended soon after the issue of the committee's first report in 1901. The word "Belleville" does not occur in the index to the second volume of THE ENGINEER* for 1902, nor does Brassey's annual of 1903 make any comments. There remained the Belleville-boilered ships. Due to their earlier treatment, or to congenital defects, there were a few Belleville ships which remained "lame ducks" at the opening of the first world war, notably "Canopus," upon which, for a time after the lost battle of Coronel, the defence of the Falkland Isles solely depended. They had the reputation of driving their engineer officers to breakdown, or even insanity.

Unquestionably the Belleville boiler acquired a bad name far less through its own defects than through its association with defective other machinery. Nor should the effect of the mistaken loyalty of many naval engineers to the Scotch boiler be overlooked. That loyalty was exemplified up to a few years ago, by an elderly retired marine engineer—a regular attendant at the meetings of the Institute of Marine Engineers—who would generally find the opportunity, no matter how apparently irrelevant to the paper under discussion—to get up and say, "There is naething like the Scots boiler !"

THE BELLEVILLE BOILER

So much for the "battle," now for some detail of the subject thereof. What was the design of this boiler that became the subject of a "battle" ?

The drawings, Figs. 2 and 3, are redrawn from the issue of THE ENGINEER for April 7, 1899, and show the boilers of H.M.S. "Spartiate," a later "Diadem" class cruiser laid down in 1897. A Belleville boiler was built up of a number of flattened spirals or elements, each composed of straight tubes of large diameter—4½in—screwed into malleable cast iron junction boxes at either end, those in front having hand hole doors. These elements rose from a common feed box in front of the boiler, and delivered into a cylindrical steam drum at the top, which was fitted with a system of baffles to prevent priming. Water level was about four rows from the top. Under steam, feed entered the steam drum, descended to the feed box by downcomer pipes—one at either end—through mud drums, which slowed down the flow, and captured any sediment, which could be blown down as needed.

The automatic feed control consisted of a chamber with float, whose movement varied with the water level, and depended for its efficient working on the almost frictionless movement of a spindle in a gland packed with "Belleville" packing—a metallic mixture, then a patent. A rod was attached to a lever from this spindle, and one could tell if water was passing by feeling it, while if pulled down it admitted extra water. Later automatics have improved on the Belleville and need less care and attention. In ships in which the writer served, the care of these automatics—forty-three in "Good Hope"—was the special duty of one mechanic. They were found to be completely satisfactory and reliable. But unfortunately, the Admiralty—probably from some economic motive—issued a packing to its own specification, which led to much trouble. Chief Engineer Gaudin, upon whose report it will be remembered the Admiralty adopted the boiler, refused to use this substitute, and eventually the Admiralty produced either the real thing, or a true equivalent.

The importance of automatic feeding, now realised as essential where the relation between water content, and steam production is small, was impressed on the writer by Gaudin when first reporting to him on joining the "Spartiate"—Fig. 1. Having replied in the negative to Gaudin's question, "Do you know anything about Belleville boilers ?" the writer was directed, "Go along and pack an automatic gland, then you will know all about Belleville boilers !"

Economisers were fitted, except in the earliest ships, built up of similar, but smaller, elements to those of the main boilers—see Fig. 3. They preheated the feed, and were invaluable in Fleet work for controlling the output of steam on sudden stoppages or alterations in speed. By flinging open their doors, draught could be checked, and the discharge of clouds of smoke—so important in coal-burning days—prevented.

A unique device was the junction of the bottom of the element to the feed-box by means of a single "anchor" bolt, with a coned nickel sleeve as the jointing material. This, the most delicate part of the boiler, unfortunately, needed more gentle handling and treatment than was reasonably to be expected from men only accustomed to cylindrical boilers, and the traditional use of a good deal of brute force in their maintenance. Freedom of expansion of the back junction was thus provided for, but it was important that this back box did not get fixed by the accumulation of soot. The disastrous and fatal explosion in "Good Hope" at Gibraltar, soon after her return from the much-publicised trip to the Cape of Joseph Chamberlain in 1904, occurred when the anchor bolts were being tightened under steam. This accident, of course, revived all the old distrust of the Belleville and, in fact, of all water-tube boilers, and probably further delayed their introduction into the Merchant Navy.

A troublesome fitting, later discarded as unnecessary, and almost an inventor's fad, was the provision of fusible plugs in two of the front junction boxes of each element. They were intended to blow if water level reached danger point. But they frequently blew without real cause. In theory they could then be replaced by means of a "pistol." But few became expert in the use of this device and the majority never succeeded in mastering it. Such replacements under steam were seldom reliable. So the plugs were usually riveted over inside when the boiler was cold, or, contrary to regulation, replaced by steel "plugs," leaving the care of the water level to the automatics and watchkeepers. After all, one or more jets of steam at 350 lb pressure, though only through a $\frac{3}{16}$ orifice, were found very disconcerting to efficient firing, during the time when someone on the floor plate struggled to stop them with a pistol !

Blowing engines were a part of the outfit, to supply air above the coal surface, but with good stoking their use was often discarded, though they were useful for tube sweeping in harbour.

Feed pumps were of Belleville design, up to and including the "Spartiate" class, but were superseded by Weir's in "Good Hope" class and later ships. Though no doubt satisfactory for the steady steaming of merchant ships, under service conditions they would suddenly and unaccountably stop. It was necessary to keep a heavy copper hammer hanging by each pump, from which a blow on the valve arm would usually restore them to duty ! Weir pumps were a very great improvement, though the larger sizes resented having to deal with the light work of harbour steaming, and would not have responded to a copper hammer ! They were kept in good behaviour by close and frequent attention to the fit of the shuttle, and like the automatics received the constant attention of one mechanic.

The boiler working pressure of 350 lb or 300 lb was reduced to 250 lb by a large valve in the engine-room, which also acted as a separator in case of priming. Another fitting, abandoned almost from the first, was a non-return valve in the down-comer, but the positive circulation later found to be assured proved it unnecessary and, in fact, with sudden changes of steam output, it probably had an effect quite opposed to its intention.

The Committee of Inquiry listed four primary defects in the Belleville boiler :

(*a*) Defective circulation.
(*b*) Necessity of an automatic feed.
(*c*) Feed pressure greater than steam pressure.
(*d*) False reading of gauge glasses.

Chief Inspector of Machinery J. A. Smith did not agree, but the prestige of the rest of the committee smothered his objections. In the light of modern experience and practice these objections seem quaint, especially (*b*) and (*c*), which are now common practice. That the circulation was defective was not true. There is no boiler to this day where the circulation is more direct and positive, and in many modern boilers the travel of the steam, or steam and water mixture, is far longer than the 50ft that so startled the committee. The last objection sprang from inherited distrust of anything but hand control, and memory of disasters that had occurred in cylindrical boilers from water shortage.

The committee also commented on the insufficient preliminary instruction given to those in charge. It may, indeed, be taken as a compliment to the engineering branch of the Navy, that it was capable of taking on such a novelty, without special courses or books of instructions without much more trouble than actually occurred.

(*To be continued*)

* This is true. Nevertheless there are references to Belleville boilers in the volume.—ED., THE E.

Royal Show at Windsor

No. III—(*Concluded from page 60, July 9th*)

THE Royal Show, which this year was held in Windsor Great Park, closed on Friday evening last after four very successful days. During the four days the show was visited by 142,000 people, which represented the biggest attendance since 1949, when the "Royal" was held at Shrewsbury. The last occasion on which the show was staged in Windsor Great Park was in 1939, when the Royal Agricultural Society of England celebrated its centenary.

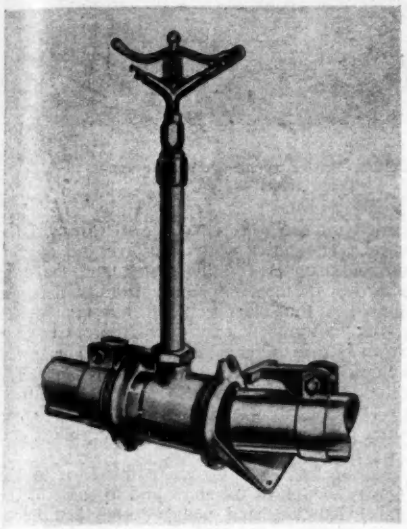


Fig. 16—Wright Rain sprinkler with quick-action coupling

That show was open for five days and the total attendance was just over 118,000.

Last week, there was again plenty of evidence of the keen interest which continues to be taken in the development of agricultural machinery and implements. That interest was not confined to the exhibits of the larger machinery manufacturers, for we noted that the stands of the smaller manufacturing firms also attracted good numbers of visitors each day. The implements and machines accepted for adjudication for the Royal Agricultural Society's silver medal awards were, as usual, varied. The regulations governing the silver medal awards are that "the implement must either fulfil a purpose of definite value for agricultural or estate purpose for which no machine has been available hitherto; or, if the purpose is not new, must embody some new principle of working which is of advantage for agricultural or estate purpose." The task of adjudication was undertaken this year by Mr. A. Herbert Carter, Mr. Leslie Langmead, and Mr. Rex Paterson. Of the twenty-three accepted entries, five were deferred until next year in order to allow further tests to be made, and the following were awarded silver medals:—Cooch and Sons, Ltd., for a vegetable washing machine; Dorman Sprayer Company, Ltd., for a knapsack pneumatic sprayer; Ransomes, Sims and Jefferies, Ltd., for the "Vibro-Hoe"; Silorators, Ltd., for the "Silorator Hayter" forage harvester; Stanhay (Ashford), Ltd., for a seed spacing drill; Edward Thomas and Co. (Oswestry), Ltd., for a mechanically operated gate; Vaccar, Ltd., for a milk flow indicator, and Wright Rain, Ltd., for a sprinkler irrigation system.

The irrigation system, which has been developed by Wright Rain, Ltd., Crowe, Ringwood, Hants, was also awarded the Burke trophy. The system incorporates piping, quick-acting couplings, hydrants, tees and rotary sprinklers which are all made from lightweight alloys. The pipes are available in five sizes from 2in to 6in outside diameter and in standard lengths of 30ft and 35ft for use in this country. For overseas use the pipes are supplied in lengths of 20ft. The pipe coupling, which incorporates a rubber washer, is automatically sealed by the pressure of the water, and there is a guard apron on the coupling which provides a lead and prevents soil from entering the pipe. As the pipe is pushed home, the latch on it is raised by a specially shaped lip on the pipe, the latch falling into position as the joint is completed. To uncouple, the pipe is pushed home still further and the latch is lifted by the coupling lip; a quarter turn then releases the latch and the pipe is free to be withdrawn. The rotation of the sprinkler is effected by water issuing from one of the nozzles; the rotation is entirely automatic and is independent of variation in the water pressure. The balance of the sprinkler and swing arm is such that even though the head may be operating at an angle, rotation continues quite evenly. Sprinklers are located in the lateral spray lines at intervals of 35ft, and

Fig. 19—Dorman "Osprey" pneumatic sprayer. Its weight, when charged, is 34 lb

variation can be made in the quantity of water applied by fitting different size jets. The arrangement of the coupling and sprinkler is illustrated in Fig. 16.

A number of spraying equipments were shown by the Dorman Sprayer Company, Ltd., 408, Cherry Hinton Road, Cambridge. One of them, for which a silver medal was awarded, is the "Osprey" portable pneumatic sprayer, which is illustrated by Fig. 19. The weight of the sprayer complete with hand lances, hose and nozzles is 14 lb empty and 34 lb when charged with 2 gallons of liquid. The tank is made from two deep-drawn copper pressings with one circumferential joint and a screw top which gives 3½in diameter access for cleaning purposes. The tank is supported on a copper plinth and the saddle is fitted at the lower end of the tank with two carrying straps. The charging port incorporates a non-return valve with a pressure regulator and siphon tube, the pressure gauge showing the cylinder pressure when not spraying and automatically changing to nozzle pressure as soon as the lance is opened. Spraying pressure can be

Fig. 17—Marshall 7 h.p. single-cylinder steam traction engine "Britannia," built in 1906

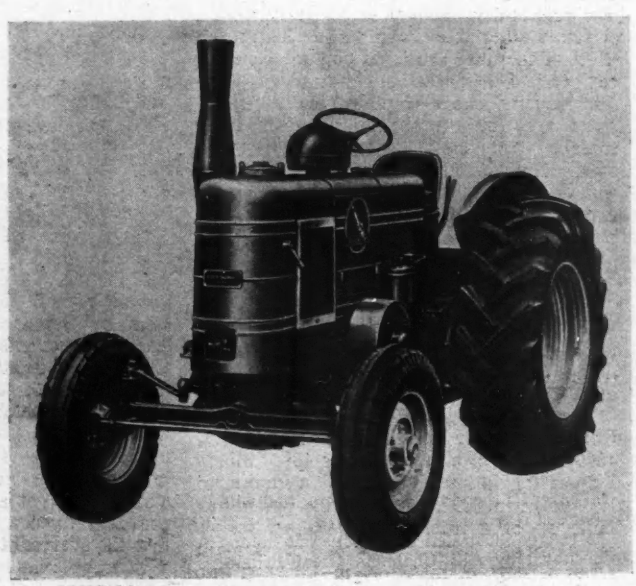


Fig. 18—"Field-Marshall" wheeled tractor equipped with single-cylinder 40 b.h.p. diesel engine

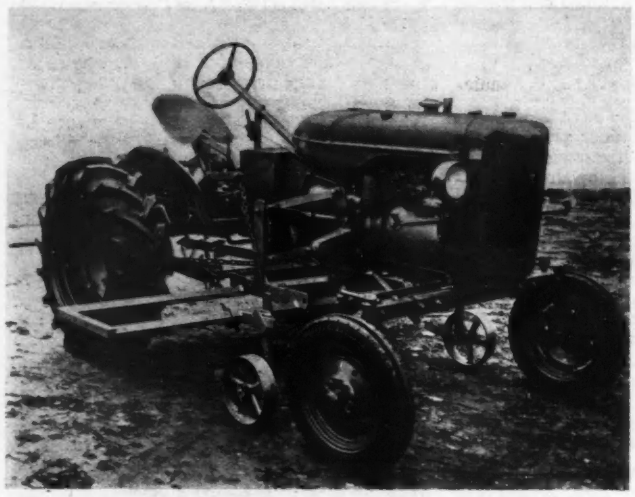


Fig. 19—Allis-Chalmers model " B " 25 b.h.p. tractor fitted with hydraulically-controlled mid-mounted tool bar

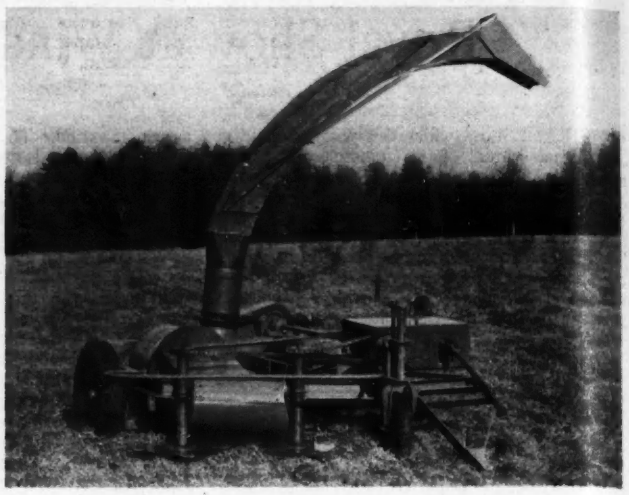


Fig. 20—Silorator-Hayter tractor-operated forage harvester

regulated from cylinder pressure, and is about 90 lb down to 10 lb per square inch. The outlet for the liquid is through rubber hose and a trigger-operated lance which is equipped with a fine spray nozzle. The single-stage pump, of 1in diameter barrel and 12in stroke, is independent of the sprayer and is supplied with suction and delivery hose, a bayonet connection being fitted to the delivery tube for coupling to the spray tank. Alternatively, a two-stage pump is available, and for low-pressure pumping a barrel of 1¾in diameter is provided, which is interlocking with the high-pressure 1in diameter barrel. Where the single-stage pump is used a bayonet fitting incorporating a Schrader valve can be supplied so that air can be charged into the container with a foot pump or from a compressor line.

The steam traction engine illustrated by Fig. 17 was a historical exhibit on the stand of Marshall, Sons and Co., Ltd., Gainsborough. Throughout the show it was under steam, and its smooth running brought many words of commendation from those who paused to take a look at a method of power for agriculture which is now almost a thing of the past. This engine, which is named the " Britannia," was built in 1906 by Marshall, Sons and Co., Ltd., and although it is described as a general-purpose traction engine, its main use was for driving threshing tackle, in which it was regularly employed until about two years ago. The engine has a single cylinder, and gives 7 h.p. at a steam pressure of 140 lb per square inch.

The present-day products of Marshall, Sons and Co., Ltd., and of John Fowler and Co. (Leeds), Ltd., with which it is now associated, were well represented at the show. Alongside the steam traction engine there was displayed the Field Marshall " Series 3A " wheeled tractor (Fig. 18), which, as well as its many land uses, is frequently employed for driving threshers and on other stationary work. This tractor has a single-cylinder, two-stroke diesel engine, 6½in bore and 9in stroke, which develops 40 b.h.p. at 750 r.p.m. The gearbox is arranged to give six forward speeds between 2·6 and 9·1 m.p.h. and two reverse speeds of 2 and 4·3 m.p.h. The belt pulley, which is 17in in diameter, with a face width of 6½in, is integral with the engine clutch and is operated by a foot pedal or a hand lever. The governed pulley speed is from 500 r.p.m. to a maximum of 750 r.p.m., providing belt speeds from 2200ft per minute to a maximum of 3340ft per minute. Among other exhibits on the stand there was a Marshall " 626 " combine harvester which has been equipped with a " Welger " straw press, and a Fowler " Challenger 1 " diesel crawler tractor, fitted with a two-speed reversible logging winch.

The tractor illustrated by Fig. 19 was among those shown by Allis-Chalmers Great Britain, Ltd., Totton, Southampton. It is an example of the firm's model " B " tractor and is available with Allis-Chalmers petrol or vaporising oil engines, or with a Perkins " P3 " diesel engine, which develops 25 b.h.p. at a governed speed of 1500 r.p.m. Both the front and rear wheels of this tractor are adjustable for tread and there is ample space for an underslung toolbar. The tractor illustrated is fitted with a " clear vision " hydraulically operated tool frame which has been introduced recently by Allis-Chalmers Great Britain, Ltd. This tool frame consists of double parallel welded bars 8ft 4in long, and can be centrally or rear mounted by attachment to the three-point linkage of the tractor. Adjustable depth control wheels are part of the equipment and, for use when the frame is centrally mounted, there is a single bar of corresponding length which is mounted at the back of the tractor and acts as a track eliminator. The top link of the parallel frame can be adjusted by a hand screw to level or tilt the frame when necessary.

The machine for which Silorators, Ltd., 103, Park Street, London, W.1, received a silver medal is the " Silorator Hayter " forage harvester, illustrated by Fig. 20. Actually, it is a combination of two machines, a " Silorator " blower-conveyor having been assembled on a rotary cutting machine made by Hayters, Ltd., Bishop's Stortford, Herts. The harvester is suitable for all normal forage crops, including maize, and is operated by the power take-off shaft of a tractor. The machine is assembled on a semi-rectangular channel frame, which is mounted on two pneumatic-tyred rear wheels and a smaller front castor wheel. The cutter blades are arranged on two horizontal contra-rotating plates, and the crop is thrown by them into the bottom of the inlet chute. A four-bladed, belt-driven fan rotates in the " Silorator " casing and the cut crop is blown into a trailer which can either be towed alongside or hitched behind the machine. The initial drive from the power take-off shaft is by Hardy Spicer couplings, the drive to the cutter heads being by single grooved pulleys and " C " section-link belting.

In our last issue we made reference to the forestry section of the show and to some of the timber handling and woodworking equipment exhibited adjacent to it. In this section, Universal Power Drives, Ltd., Perivale, Middlesex, showed the " Hannibal " timber tractor (Fig. 21), which is four-wheel driven, the power unit being a five-cylinder Gardner engine rated at 85 b.h.p. Power from the engine is transmitted through a five-speed primary gearbox, compounded with two speeds in the transfer case to the front and back axles. The winch with which the tractor is equipped is driven through the five speeds and the reverse of the primary gearbox, the rope pull ranging from 68,000 lb at 28ft per minute to 8400 lb at 215ft per minute. The standard rope equipment is 100 yards of 2¼in circumference cable with a breaking stress of 15 tons.

A new machine which has been developed by

Fig. 21—" Hannibal " four-wheel drive tractor for timber transport

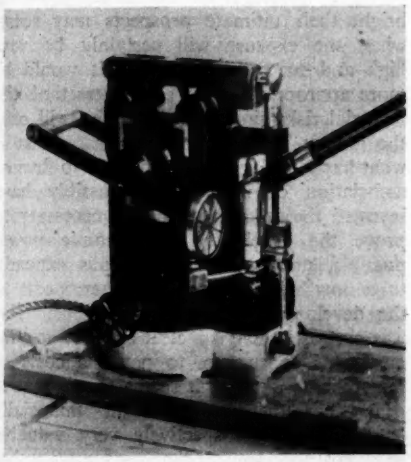
the firm was also exhibited. It is a four-wheel drive, hydraulically-operated shovel, powered by a Gardner five-cylinder diesel engine developing 94 b.h.p. at 1700 r.p.m., with a maximum torque of 300 lb-ft at 1300 r.p.m. The 14in Lipe single dry plate clutch is fully enclosed, and the gearing is arranged to give five forward and five reverse speeds. The front axle driving and steering ends are fitted with Rzeppa constant velocity high angle universal joints and there is power assisted steering. The Keelavite hydraulic system includes 5in diameter main lifting rams and 4in diameter tipping rams operating at 1500 lb per square inch.

In various parts of the show there was a great deal of horticultural equipment to be seen. One interesting item of this equipment was a plant irradiator exhibited by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. The aluminium reflector has been designed to concentrate the maximum amount of energy over the working area. An "Osram" 400W soft glass mercury lamp is incorporated and to enable the lamp to be burned horizontally a magnetic deflector is fitted to the reflector. The standard mounting height from the bench to the edge of the reflector is 3ft 3in and it is claimed that an installation of six irradiators is sufficient for 1515 tomato seedlings per batch in 3½in pots. It is also claimed that irradiated plants have flowered as much as two weeks earlier than untreated plants.

Compression Joints for S.C.A. Overhead Line Conductors

RECENTLY we visited the testing laboratories of Mr. R. H. H. Stanger, Summerfield House, Barnet Lane, Elstree, to witness tensile tests on steel-cored aluminium conductors equipped with compression joints and dead ends made by A. Salvi and Co., of Milan. The tests were preceded by a demonstration of the making of joints by the use of the Salvi compressor.

Although these joints are in use on the Continent and elsewhere they are not yet in service in this country and the accompanying sketches, which are not to scale, will serve to illustrate the principle as applied to dead ends and joints. In either case the joints depend on friction resulting from pressure produced by a hexagonal die on sleeves surrounding the wires to be jointed; separate joints are made, first for the steel core



Hydraulic compressor fitted with hexagonal dies for making compression joints and dead ends for S.C.A. overhead line conductors

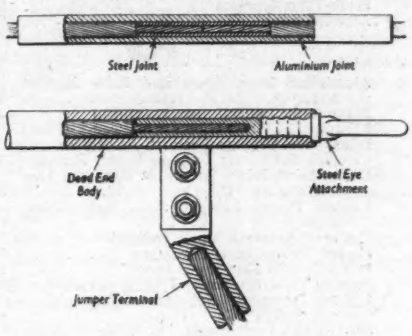
and, secondly, for the stranded conductor. The external pressure on the sleeves is produced by a hand-operated compressor which, as illustrated herewith, is fitted with hexagonal split dies. The initial diameter of the sleeve and the width across the flats of the hexagonal dies are so proportioned that when the sleeve is in position the two halves of the die are separated by a predetermined amount. When the compressor lever is operated by hand the jaws of the die are gradually brought together and pressure is exerted evenly on the sleeve by the six faces of the hexagonal dies. The process is complete when the jaws of the die are closed and, assuming that the parts are correctly dimensioned, the inner surface of the sleeve will be in intimate contact with the stranded conductor, making a frictional joint which is stated to be impervious to water.

In the case of the dead end, the principle of which is illustrated in the lower diagram, the dead end body is first slipped on the S.C.A. conductor. The aluminium strands are cut back (after serving the core and strands with thin galvanised wire to preserve the lay) to allow the steel eye attachment to be slipped over the core. The sleeved portion of the attachment is then compressed, beginning at the corrugated end and proceeding in a series of overlapping stages until the whole length has been compressed. The dead end is then slipped back to the eye and is likewise compressed, first at the corrugated part of the eye and then at the conductor end. A similar process is used for making the compression joints as typified in the upper diagram.

In the Salvi compressor the pressure on the dies is produced hydraulically through the medium of a self-contained, hand-operated plunger pump. The upper half die is fixed while the lower half is screwed to the main plunger which operates with a leather cup washer in a cylinder machined in the drop-forged steel body of the compressor. Below this body there is an aluminium alloy reservoir which contains the working fluid and forms the base of the compressor. The pump is fitted with a small plunger actuated by a pump rocker arm and is integral with the compressor. The equipment is complete with a pressure gauge and a safety valve assembly, the maximum working pressure being 14,200 lb per square inch, while the value reached in the demonstration that we witnessed was about 13,000 lb per square inch.

Referring to the photograph reproduced here, it will be seen that the upper half die is kept in correct alignment by two guides fitted to the middle of a steel closing bar which holds together the upper ends of the shoulders of the compressor. The lower half die is kept in alignment between the two arms of the retracting lever whereby the die and plunger are rapidly moved back after the release valve has been operated by turning the handwheel at the base of the compressor.

During our visit to the Stanger laboratories we witnessed a number of tests on lengths of steel-cored aluminium conductors with Salvi compression joints and compression dead ends. The tests were carried out in the presence of representatives of the B.E.A., consulting engineers, overhead line contractors and of Commandatore A. Salvi, the chairman of the company responsible for the development of these joints. The test lengths were loaded in tension in a test frame of 25 tons capacity and the results are tabulated herewith.



Components (not to scale) of compression joint and dead end for S.C.A. conductors

In Test No. 1 the test sample consisted of "Zebra" S.C.A. conductor to B.S. 215, copper equivalent 0·4 square inch, 54/0·125 strands of aluminium over 7/0·125 strands of steel, with a nominal ultimate breaking strength of 29,250 lb; two lengths were jointed with a Salvi compression joint and dead ends were fitted to the free ends of the conductors to give a test length of 25ft.

In test No. 2 the same conductor was used, but without a joint, the free length of conductor between dead ends being 21ft.

In test No. 6 the test length had been assembled in the company's works at Milan; otherwise the assembly was the same as for test No. 1.

In test No. 3 the test sample consisted of "Lynx" S.C.A. conductor to B.S. 215, copper equivalent 0·175 square inch, 30/0·110 strands of aluminium over 7/0·110 strands of steel, with a nominal ultimate breaking strength of 17,530 lb; two lengths were jointed with a Salvi compression joint and dead ends were fitted to the free ends of the conductors to give a test length of 25ft.

In test No. 4 the same conductor was used but without a joint, the free length of conductor between dead ends being 20ft 6in.

In test No. 5 the assembly was the same as for test No. 3, except that the fittings had been assembled in the company's works at Milan.

The fittings for the joints described in this article are made by A. Salvi and Co., Ltd., Milan, which is represented in this country by Ferrum (England), Ltd., Stafford House, 43, Norfolk Street, London, W.C.2.

Summary of Test Results on Steel Cored Aluminium Conductors Equipped with Salvi Compression Joints and Dead Ends

Test No.	Conductor	Test length, ft	Free length of conductor between dead end and joint, ft in	Overall length of joint after making, in	Tensile load sustained for 1 minute, lb	Ultimate load, lb	Failure
1	"Zebra" ...	25	8 6	34½	—	28,500	One conductor pulled away from central joint
2	"Zebra" ...	—	21 0	—	29,000	29,400	Conductor fractured in one of the fittings
3	"Lynx" ...	25	9 3	26½	16,800	17,600	Conductor fractured in one of the fittings
4	"Lynx" ...	—	20 6	—	16,800	17,600	Conductor fractured in one of the fittings
5	"Lynx" ...	25	9 3	26½	16,800	18,600	Conductor fractured in one of the fittings
6	"Zebra" ...	—	9 11	34½	—	27,750	Conductor fractured in one of the fittings

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PEACE-TIME RESEARCH

In the sixth Thornton lecture before the Association of Mining Electrical and Mechanical Engineers, reprinted in part upon another page, Sir Harold Roxbee-Cox compared the range of work which is described as research and development to the spectrum of light. At the left-hand or red end of the spectrum there is to be found pure fundamental research originating in scientific curiosity; at the right-hand or pure violet end there is straightforward development, that detailed practical improvement which over the years produces little change in the appearance of a machine or a device but which adds immensely to its efficiency, its reliability or its accuracy. Sir Harold stressed that advances do not usually or even often come through a regular progress along the spectrum from the red towards the violet. For, arising out of some fundamental discovery there is a "rapid proliferation of possible routes" towards practical applications as movement along the spectrum is made. To choose in this maze a route leading directly towards a successful application is thus nearly impossible. Only a very few men of really great insight have been able to achieve it; and only then when, as for example in the development of the atomic bomb, a very clearly seen and decidedly limited objective lay ahead. The more usual line of advance starts nearer the violet end of the spectrum, again with a limited objective. But to achieve that objective it may well be found that repeatedly movements have to be made towards the red end instead of towards the violet. The classic example of this approach is provided by the development of the Whittle gas turbine, where, given the fundamental idea of the advantages of jet propulsion, the approach was made by building an experimental machine and by learning from that machine how to build a better one and what researches of a more fundamental kind would have to be conducted before a still better one could be built.

Sir Harold remarked in the course of his lecture that there was little that could be done to encourage more fundamental research. It depends, indeed, upon a supply of men with the right qualities of mind for original thought, men of a kind, in any case, that this country seems richly capable of breeding. But he did feel that industry in general could engage in much more of the kind of research and development that is originated nearer the violet end of the spectrum. Basically it is impossible to disagree with him. For war experience has shown how immensely valuable research of that character can prove to be. Unfortunately, however, it is hardly possible to argue from war experience to peace-time business. For when an enemy is at the gate a man is willing to sacrifice all else to keep him out. Expense becomes no object. Life itself is at stake. But in peace-time the same man must weigh against the estimated cost of a development—a cost nearly always under-estimated since unforeseen difficulties are much more likely to appear than unexpected simplifications—what economic returns can justifiably be expected. Under those circumstances the management of a firm is always more likely to choose that kind of development well demonstrated by the continuous detailed improvement of the "Merlin" engine to give 2000 h.p., in place of the original 850 h.p., than to embark upon work problematically capable of originating something much more novel. For the costs of improving an already well-established machine can be closely estimated and the return upon the investment can be calculated; whereas to develop something new is to embark upon a more hazardous course, costing an imponderable amount, with the possibility present that in the end there may be no return at all. In war the consumer, in the form of the Government, pays the costs and willingly takes the risks. But in peace-time it is the manufacturer who is expected to pay the cost and to take the risk of failure. He can, it is true, recoup his expenditure from the consumer; but only should the work prove successful. The accountant element, necessarily present upon any board of management, is always frightened of such a research programme. Its economics are in doubt. The situation is far less frightening to a Government which can devote regularly each year some specific sum to research and which does not have to demonstrate where the profit lies in the transaction.

In fact, of course, it is ultimately the consumer who pays for research and development. For war purposes, where the Government is the consumer the payment is direct. In peace-time and for civil purposes, however, the payment is indirect. The consumer who benefits, in fact, far more directly and far more fully than does the manufacturer from the improvement in the performance of any device plays little or no direct part in encouraging research and development. Sometimes, indeed, a rich consumer may finance a research. Some of the nationalised industries do so. More generally, however, all that manufacturing firms get from consumers of their goods is criticism and complaints about their cost! Their real incentive to research and development arises far less from an innate desire to improve their products—though to their credit many firms have such a desire—than from an abiding fear that competitors will get ahead of them! Certainly it seems to us too much to expect that firms, or even research associations supported by numbers of firms, should be asked to indulge in researches, however bright their ultimate prospects may seem, when the expense will certainly be very high and success hazardous. It would be more appropriate if the consumers took the financial risks since it is they who will reap the greater benefits from success. That is what happens for war purposes. No firm or association of firms could possibly have invested the amount of money necessary to prove the development of atomic power possible, nor meet the enormous expenditures now being devoted by governments to the development of rocket weapons. For war purposes there is a clear case for governments, as consumers, to pay the costs of researches. Equally, it seems to us, that in peace-time there are certain financially hazardous yet prospectively very valuable works of development that consumers rather than manufacturers should be expected to finance. That, of course, since few financially powerful organisations of consumers exist, must necessarily mean the Government. At least within the Ministry of Fuel and Power that justification for Government intervention has been recognised. It was, indeed, one of the purposes of Sir Harold's lecture to direct attention once again to the various researches it is supporting.

ATOMIC POWER

Just after the war against Japan had been brought to a sudden end by the attacks on Hiroshima and Nagasaki by the dropping of two atom bombs it would not have been at all difficult to find people to confess to a wish that the secret of releasing atomic energy had never been discovered. But now, some nine years later, despite the fact that an arms race has developed in the

production of atomic and the still more powerful thermo-nuclear weapons, despite the fact that hopes of any kind of international control are fading, it is becoming each year more clear how great may be the benefits that civilian uses of atomic energy may confer upon the human race. Moreover, judging from a recent broadcast talk by Sir George Thomson, even the process that goes on in the terrible hydrogen bomb is not regarded by scientists as wholly impracticable of application for civilian purposes.

Engineers, probably, are more sanguine about the prospective benefits to human beings of atomic energy than is the general public. For they are better aware how vigorously the building of atomic energy reactors is being pursued on both sides of the Atlantic and how in the near future we are likely to see a large variety of different types being produced. The number of designs of which we hear—from the U.S.A. especially—is likely to provide electric supply corporations and other potential users with a generous choice from which to make selection. Indeed, in an article lately published by an American journal the claim is made that there can hardly be said to be at present any such thing as a "typical reactor," since any of them can make use of such a variety of materials whether metals, salts, or oxides formed into "pills, plates, powders, prisms, rods or threads," or even liquids. Moreover, any of them may be associated with graphite, heavy water, or beryllium as moderators to control the speed of the neutrons. Still less can one speak of any typical-reactor running costs; so the future is hard to forecast, especially in view of the limitation, for security reasons, in the information available for publication.

We mentioned in our issue of June 4th the industrial enterprise shown by the arrival of an atomic pile "catalogue" from an aviation firm in Downey, California; it describes the various forms of reactor which that firm is ready to design and build for others, subject, of course, to the approval of the U.S. Atomic Energy Commission. Coming nearer home, the British official publication, "Britain's Atomic Factories" (H.M.S.O.), gives an account of how the Division of Atomic Energy Production has built up, in less than five years, a new industry worth some scores of millions of pounds. Mr. J. R. Beard said recently in his presidential address to the British Electrical Power Convention: "It appears probable that in the quite near future not only will it be possible to produce energy from nuclear fuel in natural uranium reactors on a large scale at a price competitive with coal, but that reactors of the enriched and breeder types may be developed to a commercial stage sooner than was expected even a year ago." So one can safely say that this new, highly technical field of industry is well on its way on both sides of the Atlantic, and that although the problems to be solved are many and intricate the current supply of fossil fuels is likely, on the most moderate estimate, to be amply sufficient to afford time for their solution. Furthermore it now seems probable that a flow of information across the Atlantic between the United States and Britain will now be permitted. If it is, the flow will by no means be all one way. If the Americans can certainly tell us more about the construction and capabilities of hydrogen bombs, we, for our part, may well have information to impart about the application of atomic power for civilian purposes.

Obituary

F. H. JONES

We regret to record the death of Mr. Frank Harding Jones, M.I.C.E., which occurred at 78, Kensington Court, London, W.8, on Friday last, July 9th. Mr. Jones, who was in his eighty-first year, occupied a prominent position for many years in this country's gas industry. He was born in London and was the son of the late H. E. Jones, a former president of the Institution of Civil Engineers and of the Institution of Gas Engineers.

Frank Jones was educated at Rugby, and became subsequently a pupil of Sir John Wolfe Barry, to whom later he acted as assistant engineer during the building of Tower Bridge. He occupied similar positions during the carrying out of many other engineering projects, including the Glasgow railway subway. Mr. Jones then spent some years with his father in consulting engineering practice in Westminster, and thereafter became a director and chairman of many gas companies in this country and abroad, and some water supply undertakings. He was appointed to the board of the South Metropolitan Gas Company in 1912, becoming chairman and president of the company in 1937. Mr. Jones was quick to appreciate the advantages to be derived from larger administrative units for gas supply, and consequently took an important part in the negotiations leading to the amalgamation of many gas companies. Mr. Jones was chairman of the Herts and Essex Waterworks Company, and of the General Hydraulic Power Company, Ltd. He retired from these companies and from the gas undertakings, with which he had been for so long associated, in 1949.

Mr. Jones was chairman of the British Commercial Gas Association in 1928, and was also the last president—his father having been the first—of the National Gas Council. For more than forty years Mr. Jones lived at Matching, near Harlow, Essex, where he took a keen and active interest in many local and county affairs.

C. F. DAVIS

We note with regret the death of Mr. Clement Frederick Davis, A.M.I.C.E., which occurred at the age of eighty-three, on July 6th, at Milland House, Bar End, Winchester. Mr. Davis was educated at Dulwich College and Trinity College, Cambridge, and gained much of his early engineering experience with Messrs. Kennedy and Donkin. His particular interest at that time was in various public utility works and in the development of electric traction in this country. At a later stage of his career, Mr. Davis worked for a time on engine development at the Royal Aircraft Factory (as it was then called) at Farnborough. In 1914, he joined the electrical engineering staff of the old London and North-Western Railway and when it was merged in the London, Midland and Scottish Railway Company he became assistant chief engineer (electrical). Mr. Davis retired from that position in 1934.

Literature

Prestressed Concrete Design and Construction. By F. Walley. Published for the Ministry of Works by Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2. Price 30s.

This is a useful addition to the growing number of volumes dealing with the subject. Apart from two short introductory chapters, six chapters are given on the various aspects of design, comprising design, behaviour of prestressed concrete, materials and allowable stresses, losses in prestressing, experimental work and special design problems, and one chapter on prestressing in practice. Thus the author has drawn on his clearly considerable experience of prestressed concrete in presenting a book which, although claiming mainly the designers' attention, does largely succeed in its avowed object of "helping those who wish either to acquire a working knowledge of the subject, or to design members and erect structures in this material."

In parts, the book is written in language usually associated with technical papers. Whilst in most cases this makes for easier reading, it can, on occasion, disperse the reader's attention. However, students of the book will welcome the statement of opinions as well as facts; such a procedure is to be commended in this relatively young subject. The author's notation is clear and, on the whole, well chosen, though it is to be hoped that it will be possible soon to obviate the need for three suffixes.

The well-written, brief introductory chapters admirably fulfil their function. In the chapter on design much emphasis is rightly placed on the *technique* of design. This, combined with the three appendices giving much tabulated data of section properties, is of great practical use to the designer. Although, as the author states, "it should be the aim of every designer to determine a method of design which he finds easy to use," designers who have not already done so, and those who have some experience, will both find the methods presented worthy of serious study.

Apparently considerable time elapsed between the writing and publication of the book and for this reason, or possibly through choice, some useful results of recent research and developments are not given. For example, on the subject of local end block stresses, only the method proposed by Monsieur Magnel is given. It is a pity that Guyon's method and the tables pertaining thereto are not given since this method is more generally applicable, more consistent and rigorous, and frequently easier and quicker to apply. The method, published in 1951, might well have been included. Again, the author does not deal with friction effects on internal post-tensioned cables, effects which, in certain cases, can be very important. Parabolic cables are recommended in the book, but considering these effects, a cable shape consisting as much as possible of straight lines joined by large radius arcs is a considerable improvement.

When considering the shear effects of prestressing the author has discussed prestressing forces which are horizontal and those which are inclined to the horizontal. This, whilst correct within the limitation of the discussion (i.e. horizontal beams of constant section) is unfortunate, since a more general discussion of prestressing forces which are parallel to the neutral axis and inclined to the neutral axis would have been more valuable and would have presented an aspect which is by no

means obvious. In stating that no shear reinforcement need be used provided that principal tensions are not near the allowable values, the author differs from some other engineers who recommend the provision of some, generally very small, quantities of reinforcement to guard against accidental cracks. The point depends on the type of structure considered but too general statements are to be avoided since in certain structures, e.g., bridges, the provision of such steel is to be recommended.

The chapter on the behaviour of prestressed concrete under load is extremely valuable. A useful dissertation of various ultimate load formulæ is followed by the tabulated results of thirty-two specimens of various shapes and sizes giving calculated and actual ultimate bending moments. On materials and allowable stresses useful data is given. The chapter on losses in prestressing is distinguished by an excellent dissertation on the Young's Modulus of concrete. Each factor contributing to losses is clearly described, the ample graphs presented aiding the reader's appreciation of the problem. The information given will be well appreciated by the designer. A very clear description of the various methods and systems of prestressing is given in the chapter on prestressing in practice. Specially to be commended is the very objective comparison between the two major post-tensioning systems. It is a pity that the author did not extend his comments on grouting to those systems using large diameter bars for their prestressing element. The chapters on experimental work and special design problems are useful additions to the book. The author has wisely refrained from introducing any detail on continuous structures into the scope of this book since that is a problem which would need a separate volume to do it justice. Numerous examples, diagrams, graphs and photographs admirably illustrate the work.

Considering the book as a whole, it can be said that it forms a useful contribution to the literature on prestressed concrete. The subject matter is well presented in language that will appeal to the engineer. It contains a large amount of detailed information which will be helpful to the designer and has a definite place in his library.

Oil in the Soviet Union. By HEINRICH HASSMAN. London: Oxford University Press, Ltd., Amen House, Warwick Square, E.C.4. Price 30s.

THIS book, translated from the original German by Alfred M. Leeston, who added much new information for this 1953 edition, is advertised as covering the history, geography, and the problems of the Russian oil industry. This term includes, in addition to the production, transportation and refining of petroleum, the natural gas and shale oil resources of the U.S.S.R.

Parts I and II, dealing respectively with the basis and economic history of the Russian oil industry and with its development since 1860, contain much interesting information. Population, the countries comprising the U.S.S.R., historical epochs, the present constitution and the current economic system, as well as many Soviet industrial achievements, are sketchily covered in less than fifteen pages, which include two maps of the vegetation zones of European and Asiatic U.S.S.R. The development of the oil resources is, however, dealt with more seriously, and a concise picture is painted of the considerable development and progress made since the early days of the oil industry almost one hundred years ago.

The U.S.S.R. oil resources are spread throughout many and various regions, and these are quite well detailed in Part III. Included in this section are many regional maps, apparently quite up to date so far as rail and road facilities are concerned. The maps, however, fail to show what, surely, must be of the greatest interest to any reader of the book—the locations of oil and natural gas fields, shale oil areas, refineries and pipelines.

The problems facing the many regional petroleum groups are discussed in Part IV, and here, more than in the other sections, it is somewhat surprising to appreciate the ready acceptance by the author, and by the translator, of official Soviet statements and statistics issued since the U.S.S.R. became involved in World War II. Even Mr. E. de Golyer, a very eminent American petroleum authority, who wrote the Foreword, also appears to be prepared to place credence in Soviet announcements concerning their most strategically important industry. Admittedly, before 1940, facilities were afforded visitors to the U.S.S.R. to an extent whereby a reasonably accurate assessment of petroleum production, refinery capacity, &c., could be made. There is far too much evidence, however, of the close secrecy maintained since 1940 by the Russian authorities on everything affecting their security to believe that they would, of their own volition, issue accurate statistics, especially during the past few "cold war" years, concerning their increasingly important oil industry.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

BOMBS AND EDUCATION

SIR,—The two leading articles contained in your issue of May 21st have a point in common. In "The Happy Scholar" reference is made to the fact that at the opening of the century the "Classics" still ruled supreme in general approbation as the finest form of education, and that pure science was not regarded as a study fitting a man for the foremost administrative posts. In the article, "The Essential Problem of the Hydrogen Bomb," you reiterate the view that with our increasing knowledge of the hydrogen bomb the less must reasonably minded people be disposed to object to its use being banned altogether.

We have at present reached the stage at which physicists and engineers in order to study the problems of nuclear power have also to study, under political direction, the means of producing nuclear explosives of ever-increasing lethal capacity; governments being the only bodies which can provide sufficient capital for large-scale research into nuclear physics. Having developed thermo-nuclear bombs of devastating capacity, doubt exists as to whether they should be used, and suggestions are forthcoming that an effective form of international inspection will be necessary to prevent their use. This, to all rational thinkers, must appear as immensely misguided effort.

Scientists and engineers, having found means of producing nuclear explosions of such magnitude are fully aware of the dangers resulting from the propagation of radioactive particles. It is not at all certain, however, that our administrators are as fully aware of these facts, and perhaps a suitable amount of scientfic knowledge would be of use to them in these matters. It seems incumbent upon the scientific and engineering professions throughout the world, therefore, to stress the dangers which may result from nuclear explosions. If this were done enlightened public opinion might be persuaded to demand the abandonment of nuclear weapons, thus releasing more effort for the application of nuclear energy to improving man's living standards.

J. R. V. GREAVES

Kuala Lumpur,
June 26th.

FRENCH LOCOMOTIVE EXPERIENCES

SIR,—I should like to thank Mr. Livesay for his most interesting series of articles and you, Sir, for making it possible for so many of your readers to be regaled in such a delightful manner. The only complaint I have to make is of that exasperating wait for the next instalment to appear each week.

Mr. Livesay is to be envied and congratulated and THE ENGINEER complimented on its initiative. It is hoped that further accounts of such experiences will be published as, and when, Mr. Livesay has the opportunity.

E. B. PARKER

Wirral, Cheshire,
July 8th.

SIR CHARLES PARSONS

SIR,—In your issue of June 25th there is a letter from Mr. J. F. Field, commenting on the article on Sir Charles Parsons in a previous issue.

Mr. Field's statement that North Tees power station was the first station in the world incorporating reheating and feed heating is incorrect, as a small tandem machine was designed by Parsons for Blaydon power station in 1916, and later, the writer was associated with Mr. J. N. Waite in carrying out the official tests on this plant.

On this unit both the superheater and reheater were gas-fired from waste heat and very useful data were obtained.

Partial reheating was also carried out on one of the sets in Carville "B" station for a short period in 1921.

P. G. LLOYD,
Steam Testing Engineer

Dunston-on-Tyne,
July 9th.

Books Received

Deep Drawing. By J. Willis. London: Butterworths Scientific Publications, Ltd., 88, Kingsway, W.C.2. Price 25s.

The Swansea and Mumbles Railway. By C. E. Lee. Surrey: The Oakwood Press, Tanglewood, South Godstone, Surrey. Price 7s. 6d.

Metal Industry Handbook and Directory, 1954. London: The Louis Cassier Company, Ltd., Dorset House, Stamford Street, S.E.1. Price 21s.

Power System Transients. Edited by E. Openshaw Taylor. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 21s.

Colliery Year Book and Coal Trades Directory, 1954. 32nd Edition. London: The Louis Cassier Company, Ltd., Dorset House, Stamford Street, S.E.1. Price 30s.

What Every Engineer Should Know About Rubber. By W. J. S. Naunton. Published in London by the British Rubber Development Board, Market Buildings, Mark Lane, E.C.3. Price 3s. 6d.

Lubrication of Industrial and Marine Machinery. Second Edition. By the late W. G. Forbes, revised by C. L. Pope and W. T. Everitt. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 52s.

Tables of Riccati Bessel Functions for Large Arguments and Orders. Prepared by R. O. Gumprecht and C. M. Sliepcevich. London: Oxford University Press, Ltd., Amen House, Warwick Square, E.C.4. Price 28s.

Tables of Light-Scattering Functions for Spherical Particles. Parts I and II. Prepared by R. O. Gumprecht and C. M. Sliepcevich. London: Oxford University Press, Ltd., Amen House, Warwick Square, E.C.4. Price 52s.

Tables of Functions of First and Second Partial Derivatives of Legendre Polynomials. Prepared by R. O. Gumprecht and C. M. Sliepcevich. London: Oxford University Press, Ltd., Amen House, Warwick Square, E.C.4. Price 28s.

Some Notes on the Development of Fairground Machinery

By P. W. BRADLEY

No. I

Little published data exists on the equipment used by travelling showmen, yet the subject embraces many ingenious mechanisms, which have to operate under the most rigorous conditions. Additionally, designers of fairground machinery have succeeded in making even the heaviest and most complicated apparatus readily transportable. It is proposed to describe various forms of amusement rides on the basis of observation by the writer, supplemented by such limited published data as has appeared. This article surveys the growth and organisation of the fairground business in Great Britain so as to provide a background of the conditions which travelling amusement machinery has to fulfil. Transport considerations are also reviewed.

It is perhaps hardly surprising that technical writers have paid so little attention to travelling showmen's equipment, for the fairground business is highly specialised and its machinery is for the most part produced by comparatively small manufacturers, usually as a series of " one-off " jobs to individual and exacting specifications. In the matter of roundabouts and the like the available literature was virtually confined to Patent Specifications until Mr. Thomas Murphy, the General Secretary of the Showmen's Guild of Great Britain, surveyed the subject in his paper " The Evolution of Amusement Machines," presented to the Royal Society of Arts in 1951. Showmen's steam road locomotives have been described in a few recently published books, but only with reference to certain makes and types.

In recent years there have been rapid developments in fairground engineering practice. Light alloy sections have replaced heavy timbers in roundabout construction ; the last carbon arc lamp has vanished and the first fluorescent tube appeared ; while a steam engine in use, either as stationary power or for transport, has itself become something of a novelty. A slow but continuous process of riding machine evolution culminated in the complicated " Waltzer " and " Airways " of the middle 'thirties, to be succeeded by the " Moon Rocket " (and then, since the war, the " Rotor "), which reverted to simple circular motion in one plane, like the dobby horses of seventy years ago. If, then, the full circle has been turned, it seems wise to attempt to record some of this interesting history, before it is all lost and forgotten.

Yet in spite of progress, certain links with olden days remain. Old-fashioned rope-operated swing boats not only survive, but are commonplace, and the long-familiar " Big Wheel " and " Helter Skelter " are still in production, maybe assembled largely from light alloys, but nevertheless entirely traditional in outline. The writer, who is too young to have seen some of the earliest, and now extinct, mechanically propelled devices, has been repeatedly assured that " fairs really were fairs " in the days which he did not know. True as this may be, observers of the earlier period are (with rare exceptions) embarrassingly vague when asked just how some particular system of cranks, links and rollers was arranged. This, and the paucity of technical literature on the subject, result in these notes being based on personal observation to a large extent. It is too much to hope that they are precisely accurate, and they are certainly incomplete. They are offered as an attempt to set down some account of a fascinating subject which appears to be in danger of passing unrecorded. It is sincerely hoped that any reader possessing further information, particularly as regards devices to be mentioned but not described in detail, will communicate with the Editor.

It is intended first to describe the growth and organisation of the fairground business in Great Britain, so as to give a background of the conditions under which amusement machinery operates. Transport considerations will also be reviewed, for these have influenced riding machine design to an appreciable extent. Various machines will then be described, together with the transport equipment and power generating plant associated with them. Large permanent and semi-permanent " Amusement Park " devices are excluded, as is amusement machinery other than rides (such as mechanical illusions, games of skill, and slot machines). Aspects of the business other than technical are not within the scope of these notes, but useful literature does exist on fairground history, organisation and art, to which references will be made. Specialised and unusual technical terms will be dealt with as they arise.

Present-day pleasure fairs are the successors to the trading and hiring fairs of olden days. Modern methods of trading, combined with rapid transport and communications, have eliminated the need for the fair as a commercial market, and the engagement of servants and farm workers is likewise provided for by other means. Amusements in a limited form had been a feature of fairs from time immemorial, and this aspect gradually superseded the trading side. Many fairs are still known by their old and picturesque names ; Nottingham Goose Fair, for example, is referred to all over the country as " Goose Fair " ; but oddly enough, Barnet Fair, the last in the London area where trading survived on any appreciable scale, contains nothing in its title to indicate that it was primarily a horse fair. The Mop Fairs in Warwickshire and elsewhere are still followed, after an interval, by a second or " Runaway " Mop. These originated in hiring days, and were staged so as to give a servant a second chance of a year's congenial work if the employer who had engaged him or her at the first Mop did not come up to expectations. Much interesting fairground history has been chronicled by R. W. Muncey in his book *Our Old English Fairs.*

Chartered and " ancient custom " fairs are insufficient to keep showmen fully occupied. Between such events it is a case of engaging in what is termed " private business." Such events are usually controlled by a roundabout proprietor, who rents a suitable field for the desired period, builds therein his own equipment, and sublets space for games and perhaps other rides. A " private business " fair can and does appear in a town at any time, but certain old-established firms have staged these events so regularly that they, in combination with any charter and similar fairs held on specific dates in the same part of the country, together make up what is termed a " run " of fairs. There are, for example, the " Oxfordshire Back-end Run," largely made up of ancient-custom and charter fairs, and the " Regatta Run " in the West Country, composed entirely of private ones.

Another outlet for the travelling showman, of comparatively recent development, is the " Fixed " amusement park at a holiday resort. These at first contained only heavy semi-permanent equipment, but later on, travelling showmen with, perhaps, good Easter and Whitsuntide fairs and then

Fig. 1—St. Bartholomew Fair, in Smithfield, London, believed to have been established about 1123 and last held in about 1842. This engraving is understood to depict the 1808 event.

nothing very lucrative until their autumn run started, found it a sound proposition to rent space in such amusement parks, and spend July and August there with some or all of their machines. One at least of the devices which have spent the last three summers in Battersea Park had never previously remained erected on one site for more than a fortnight at a time.

The showman is emphatically not a gipsy of any kind. He and the gipsy both live in caravans, and there the resemblance ends. And it should be stated here that the writer has found the fairground fraternity to be as friendly a people as one could wish to meet. Facilities to take photographs and dimensions have often been given freely, and once it is established that one's interest amounts to something deeper than mere curiosity, reasonable questions are carefully answered. Indeed, without the co-operation of show folk themselves this series of articles could never have been attempted.

Sizes of travelling amusement businesses naturally vary, but concerns owning more than six large riding machines are few. Two to three is probably the average for the "riding master." Smaller men may own anything from one stall or game up to, say, 60ft of stallage, several round stalls and a juvenile roundabout. Very attractive, but few in number nowadays, are the little family fairs, visiting out-of-the-way villages. These usually comprise one power-driven machine, a set of swing boats, a children's roundabout and a few stalls; staffed largely or sometimes entirely by the proprietor's family. The standard of maintenance at these little fairs was often very high indeed, and attractively set out on a village green, they were indeed a picture. The average fair, nowadays, in a country town or a suburb of a larger one, comprises three to five adult machines of two or three different ownerships, and a proportionate amount of smaller equipment. The largest fairs in the country (Nottingham Goose Fair and Newcastle Town Moor Fair) each have over thirty adult rides, but they are exceptions. Over twenty is still very uncommon; nevertheless the total number of large machines in circulation has probably doubled during the last thirty years, and "too much stuff for the size of the place" is a common complaint among showfolk nowadays.

It will be apparent from this survey that the fairground industry, consisting of innumerable comparatively small businesses, would be in a chaotic state if not properly organised. For many years now the Showmen's Guild of Great Britain has undertaken this onerous task. The country is divided into several sections, each managed by an elected committee, and delegates from each section constitute the central management committee, which meets in the general secretary's office in Westminster. The central office is responsible for dealing with all matters which affect the industry as a whole, such as transport legislation and town planning matters, while the sections attend to local matters. A high standard of internal discipline is maintained, and various rules preserve member's rights to space at given fairs after a certain unbroken period of tenure. Rents are kept under constant review, and when, as happened in at least one town in 1952, municipal authorities increase rentals by an apparently unwarrantable amount, and decline to agree upon a reasonable compromise with the sectional guild committee, not one solitary stall appears when fair day comes. The very nature of the business makes the guild at once a vital necessity and yet a serious demand on the time of those elected to run it. Its history has been ably recorded in *The History of the Showmen's Guild*," a book by Mr. Thomas Murphy, the present general secretary.

Fig. 2—Part of Mitcham (Surrey) Fair in August, 1939. This fair, believed to date from Elizabethan times, was revived in 1948 and is now one of the largest in the London area

A feature of British fairs, as compared with the Continental and American counterparts, is their short duration, a factor which has had its due effect on roundabout design. Chartered fairs often open for only two days, some only for one. "Private business" events usually run from three to ten days; longer than this is unusual, except on established winter grounds in large towns, and at holiday resorts where there is a constantly changing population.

The layout of a fairground is an important consideration. All riding devices and stalls can be roughly classified into those requiring frontage space on the boundary of the fair and those which occupy an island site. This division is not absolute; a set of swingboats, for instance, can reasonably occupy either "side" or "middle" ground. Various unwritten rules govern the placing of the various attractions; for instance, large and spectacular side shows are kept together, and at the end of the fair remote from the main entrance, so as to distribute the crowds evenly. Fairground layout affects riding machine design, in that a machine must be readily adaptable to one at least of the two possible basic sitings. This usually follows as a matter of course, but machines such as the "Moon Rocket" (which from the layout point of view are a large circular structure with but one entrance and exit point) have an unenviable reputation as "ground blockers." If given an island site, the area around them, other than opposite the entrance, is "left out in the cold" (that is, side attractions facing this area will suffer); while if allocated side ground, their depth will mean projection in front of the building line, hampering free movement of the crowd.

Fairground surfaces vary from cobbled market places to wet fields. In no case are foundations (in the accepted sense) possible; firm anchorage to the ground is virtually limited to stakes which are driven, for instance, as a holdfast for chains hooked round swingboat legs as a precaution against overturning of the whole structure. Base frames of machines commonly comprise an arrangement of heavy timbers spaced apart by lighter members; the heavy timbers in such instances are levelled (themselves and relative to one another) by packing with anything from slips of thin wood to strong wooden boxes. In extreme cases, notably at Portsdown Hill, near Portsmouth, the writer has seen machines built on a slope of about 1 in 10, demanding several feet of packing on one side of a "40ft machine." In such instances oil drums or old iron water tanks are commonly employed. Fifty packing points may be involved in the erection of an adult-size machine, or even more if the ground is very soft. Nothing more elaborate than a spirit level and long straightedge are used in "setting a machine bottom." Showmen always avoid carrying ancillary equipment as far as possible, and machine components are generally stowed in their transport vehicles at such heights that they can conveniently be manhandled. The comparatively few instances where heavy indivisible components demand lifting tackle of some kind will be dealt with as they arise.

Not the least interesting feature of amusement machines is the manner in which heavy or bulky indivisible units, or assemblies containing working parts whose alignment must be accurately preserved, are so constructed as to form towable or even self-propelled road vehicles in themselves. This principle was never "invented," but seems to have developed naturally from, perhaps, the travelling menageries of olden days, wherein a number of beast wagons would be arranged in rectangular formation for showing, the shutters on the inner sides being removed. By 1880, however, the principle had been developed to a remarkable degree, as the "Sea on Land" machine of that year (to be described in a future article) will demonstrate. It soon became practically universal for roundabout centres. A little later, when most showmen transported their heavy equipment by rail, and vehicle height became all-important, "double-truck" centres were introduced, the actual centre (incorporating turntable, steam engine, and all gearing, &c.) being hauled up a ramp on to another truck every time the machine was built.

Showmen are almost always self-reliant in the matter of electricity supply. In a few towns a public supply is available, and it is a condition of tenancy that it be taken, and a proprietor spending the summer months in an established amusement park will usually find a suitable supply laid on for him. By and large, however, the showman must carry his own power plant. 110V d.c. is his standard, both for power and lighting, and nowadays it is frequently obtained from a self-contained diesel or petrol-driven generating set of up to 40kW capacity. Instances of dynamos driven from the power take-offs of motor tractors and lorries are also common; but the steam tractor or road locomotive with dynamo belt driven from the flywheel is very seldom seen nowadays, and the portable steam generating set has been extinct for many years. Each generator and its lighting and/or power load is a separate entity ; the paralleling of generators is a complication rarely attempted, although one such instance is to be described.

The English fairground enjoys an excellent accident record. Serious mishaps are extremely rare, to the extent that they attract considerable attention in the popular Press. Small fires, often electrical at source, are rather commoner, but are quickly dealt with. As in all trades, peculiar accidents sometimes occur ; a particularly unusual and tragic instance, a few years ago, being that of a showman's child breathing a fatal amount of carbon monoxide while asleep in a motor caravan, the engine of which was being used to drive a dynamo.

A good riding machine, from the owner's point of view, is obviously one of high earning capacity. Of the charges to be set against revenue, transport costs and lost potential takings while in transit are particularly important, since so many other charges are indirectly involved. It is for this reason that transport considerations will continually recur in the course of these notes, and before embarking on descriptions of various machines it may be well to review transport matters generally.

There have been three principal phases : horse, rail and mechanical road. Horse transport of stalls, swingboats and other small attractions never presented any difficulty and was commonplace until the early 'twenties. Odd instances survived much later, and may indeed still exist. The introduction of steam-powered machines, with at least one indivisible load of several tons, made it economic to use the railways for journeys of any length ; this practice grew, and with it there developed the characteristic " bow-topped " packing trucks, which would clear the loading gauge when loaded on flat railway wagons. These vehicles are still sometimes seen, rebuilt on modern running gear, but recognisable by their " railway " roof curvature. Eighteen feet was the usual length of these trucks, and they were about 7ft in width. Horses were, of course, still employed between railway station and fairground. Electric lighting was little used at this period, but those who had adopted it used small portable steam generating sets drawn by a single horse or, of course, loaded on rail.

In spite of the practical disadvantages and expenses of rail transport, showmen were not particularly quick to adopt the steam road locomotive. It was not until the turn of the century that such engines became a common part of the fairground scene, but once their worth was proved these machines were purchased in increasing numbers. Between 1904 and 1912, in particular, engine builders did a very good trade with roundabout proprietors, who, not content with a reliable prime mover which made them independent of the railways, specified and cheerfully paid for the most ornate fittings (useful and otherwise) in cast brass, and elaborate schemes of lining in gold leaf on every cool part of the engine. This was a change indeed for traction engine builders, whose previous clientele had been largely agricultural ; but they were certainly not slow to meet the demand. Lengthy trains of moderate-sized wagons were hauled by showmen's engines for a time, but later legislation restricted the number to three, plus one vehicle carrying only fuel and water for the engine. This brought about an increase in size of trailers ; vehicles 23ft to 24ft in length became common, with widths of 8ft. A few vehicles, notably the organ wagons of the largest cinema shows and some three-room living wagons, were 30ft long.

Thus the position remained until the early 'thirties. At that time the last new steam showmen's engines were built, and the petrol and diesel-engined tractor entered the field. These rapidly grew in popularity in the immediate pre-war years, and then, at the end of hostilities, when suitable vehicles became available cheaply on the surplus market, the steam locomotive virtually disappeared. The writer knows of less than half a dozen still in regular use on English fairgrounds, yet during two days in 1939 he visited fifteen fairs (all in the London area) and saw forty-five examples. Internal combustion tractors did not, at first, affect the design of transport trucks to any appreciable extent, but two became the usual load rather than three. Later, the pneumatic tyre became almost universal. Since the war air braking of trailers has been introduced and there has been a tendency in new construction to a slight reduction in overall size and a drastic reduction in weight, due to modern methods of chassis construction.

Showmen have always made full use of their transport as an advertising medium ; in one extreme case, before the war, it was said with some truth that the fair looked more attractive on the road than built up. And the story of the West Country roundabout proprietors, who ruled that engine drivers must stop and " rub up " all brasswork before passing through towns is perfectly authentic.

(To be continued)

Research and Development in Engineering

By SIR HAROLD ROXBEE COX

Research and development carries the reminder that advance is made by science and engineering, and that there are dangers in emphasising the contribution of one or the other. In this the sixth W. M. Thornton Lecture, delivered before the Association of Mining Electrical and Mechanical Engineers in Glasgow, on June 18th, the author discusses the range of research and development and the part the Government should play in encouraging it and paying for it.

Research and Development Likened to a Spectrum

I HAVE in the past likened the process of research and development to a spectrum, and the analogy is a convenient one. The red end of the spectrum is the region of invention and of fundamental research. The violet end is the region of new products—new machines, new materials, new processes. In between is the gradation of applied research—of research and development basic in its character to the left, engineering in its character to the right—by which the two ends are joined. Analogies have their dangers. The danger in this one is that of imagining that the creation of a new thing is the result of a steady progress from left to right along the spectrum. That, indeed, is one way of creating a new thing, but it is not the only way. Whilst the creation of a new thing nearly always exhibits red, orange, yellow, green, blue, indigo and violet components, it by no means follows that they must occur in that order. Research and development is rarely so tidy. To exhibit more clearly what may happen, however, I will describe two routes to the creation of new things which are quite different in character.

There is, indeed, first of all, the orderly succession represented by steadily travelling from left to right. This method requires that in the first place there is a new scientific discovery or a new invention (*R*). This new idea or set of ideas is probably next tried out in laboratory experiment and unsuspected difficulties are met and overcome (*O*). Next, perhaps, some prospect of using the new information is foreseen, the elements of a design are sketched out (*Y*), and the characteristics to be discovered from an experimental pilot-scale or full-scale test are determined (*G*). The experimental apparatus for the test is adjusted and modified until a version which works is achieved (*B*). When enough confidence has been established, a prototype, be it of an engine or a process or a new material, is designed and built, and the final stages of engineering development are begun (*I*). When, in the vulgar tongue of the development engineer, all the bugs have been got out of the design, operational trials are started (*V*). Given success in all these stages, production—perhaps of a quantity of new machines, perhaps of large new chemical plants, perhaps of some new material in a conventional plant—begins. This is the most conventional pattern of research and development.

The other route to which I referred begins, so to speak, at the other end of the spectrum, and springs from the desire to have something better in a particular field than what exists there, to devise a more efficient thing for a particular kind of duty than the thing we have for that duty—perhaps an engine of higher thermal efficiency, or a chemical process of greater economy, or a machine tool which works at a faster rate. The design of the new thing may expose ignorance which must be liquidated by research or test before a prototype is made. Perhaps testing of a prototype may expose the need for further and more basic investigation. Perhaps the increase of performance attempted proves to be such that quite fundamental work is needed, and the investigators are forced right to the red end of the spectrum before they can successfully complete the new task.

Two Schools of Thought

Between these two routes, the left-to-right and the right-to-left, there are obviously possible a large number of others illustrated by different permutations of the colours, but by and large, these two approaches represent two different schools of thought. One of these assumes, or appears to assume, that all progress will come as a result of the left-to-right approach. If they do not consciously profess any such doctrine,

their method of work implies it. They are, in fact, though they rarely know it, in a serious difficulty.

A new discovery inevitably gives rise to a number of lines of investigation and each of these may suggest a number of others. There is a rapid proliferation of possible routes and only too often the multiplication of interesting researches is such that all available endeavour is more and more concentrated upon them and the possibility of finding a route leading to an advance applicable in the service of man diminishes. The left-to-right method I described is, in fact, only rarely possible and when it is, it is so generally because of the clear vision of one interested party.

From the viewpoint of ultimate dividend to the human race, the left-to-right method can then be very wasteful. It can lead to the accumulation of a great deal of knowledge which may never be needed, or which for its exploitation would require resources out of all proportion to what could reasonably be provided. It is, however, an absolute necessary method as it sometimes leads to big dividends. The right-to-left approach is, on the contrary, economical of research effort, because the researches done are just those to enable the investigators to reach their objective, and no more.

I consider these ideas to be important because I believe that the pattern of civil research and development in this country is unbalanced. Far too much earnest endeavour ends in reports on library shelves. The total research and development effort could well be increased, but it is more important that the internal balance should be changed. There should be much more work of the right-to-left kind.

The Research and Development Spectrum in Great Britain

The existence of this unbalance at the present time is a matter of great interest as well as great importance. In these islands we are immensely strong at the red end of the spectrum. The British have always supplied a disproportionately high number of inventors and first-class fundamental scientists. In other words, we are good at original thought. If we were not, there would not be much to be done about it. The ability to invent on the grand scale—I am not thinking of the pettifogging "improvements" that are the subject of too many patent specifications—is innate, and the most we can do is to take steps to give every inventor a chance. In this connection, the setting up five years ago of the National Research Development Corporation was an important step to ensure that our inventive genius was never wasted.

In fundamental research too—genuine fundamental work exemplified by the work of such great men as Faraday, Rutherford and Clerk Maxwell—I suppose that all the people capable of doing it, are doing it. The genuinely original scientific mind brooks no denial and generous funds administered by the universities and the Department of Scientific and Industrial Research are available to provide it with reasonable facilities and sustain its body in reasonable comfort. There may be people capable of fundamental research who are not doing it, but there are many more incapable of it who are being paid to do it. That is a fault on the right side. In other words, I believe that in Great Britain fundamental research is adequately provided for and we get plenty out of it, as we do out of our inventors.

The prosperity of this country is very dependent upon its engineering industries. Their success, in turn, depends upon their ability to create new things and to improve their methods. These two abilities are, in fact, interdependent. There has in recent years been a great deal of criticism of what is described as our inability to apply the fruits of "research." What is meant is that despite our effectiveness at the red end of the spectrum, insufficient consequences at the violet end, in the form of new things we can use to enhance our prosperity, appear.

The criticism is not levelled at the defence spectrum. Our fighting aircraft, our aircraft engines, our atomic bombs, are second to none. But it is levelled at the civil industrial spectrum, and the remedy is more of the right-to-left approach, an approach which has been demonstrably successful in the aircraft field. Our civil aircraft are advanced beyond those of any other nation because they have inevitably benefited from the right-to-left approach applied, though not on their behalf, to the development of military aircraft.

The Provisioning of Research and Development

Now what, in practical terms, does this mean. It means the conscious specification of new products of greater performance than the ones they are intended to replace. It means finding the money for their achievement through the processes of research and development. It means their efficient manufacture and adoption when successful prototypes are developed. Whence should come the initiative for this? There are only two sources—Industry and Government.

By and large, we are in the business of research and development for our health. Or if not, we ought to be. It is clearly the case in the defence field. There the philosophy is clear. We decide to safeguard not only our health but our life against attacks by force of arms. We decide not only to make ourselves strong to defend ourselves, but, on the long accepted doctrine that the best method of defence is attack, we provide ourselves with weapons with which to retaliate on whoever shall assail us.

The Government accepts unquestioningly the responsibility; and, be it noted, it accepts the responsibility in the role of consumer. In other words, in its duty of defending the country, it specifies, sometimes broadly, sometimes in detail, what it wants industry to provide. And, as it is always wanting something better than it has got, it logically pays for the research and development necessary to provide it with its new things. It recognises implicitly, if not explicitly, that there are the two ways of getting new things, the left-to-right and the right-to-left; it provides for the former in its own research establishments and by enlisting the aid of Universities, and it provides for the latter by development contracts to industry.

But our national health—and I use these words without capital letters—can be assailed by subtler means than force. It is possible for a man to die from an insidious disease as well as from a blow on the head. It is possible for a nation to die from economic anæmia as well as from force of arms.

Though the responsibility of Government for research and development for defence against warlike attack is clear, its corresponding responsibility for defence against economic attack, or for the cure of internal economic weakness, is not so clear.

For many years the Government has accepted responsibility for the economic health of the nation in the sense that it has tried to correct economic out-of-balance by fiscal means. Successive governments have indeed tried diametrically opposite means to deal with the same disease. There are signs, however, of a movement from remedy by these political and *ad hoc* means towards remedy by methods which deal with causes rather than current effects.

The most obvious and best known step was the creation in 1916 of the Department of Scientific and Industrial Research. In the climate of private enterprise in which the Department was created, and in the climate of private enterprise as it exists to-day, the Government could not, however, be directly responsible for what came out of industry, nor how industry developed. It could, and did and does, however, make itself responsible for supplying to industry a nourishing pabulum and the quantity and popularity of this scientific food has steadily increased until to-day the D.S.I.R. contribution is greater than ever before. Private industry benefits in its civil work from research done in the Government's own laboratories and from research done in laboratories financed by industry and Government in collaboration. The Government contribution, however, is to sponsor work at the red end of the spectrum and so to stimulate left-to-right movements.

But, in general, the Government is not the consumer as it is in the defence field and so is not in a position to specify and order large quantities of new things. There is not, therefore, the tremendous incentive in the civil field which in the defence field comes from the Government's consumer role. What should take the Government's place in the civil field? Clearly the industrial consumer wherever he be found—the manufacturer who needs more advanced machine tools, the machine tool maker who needs new materials, the chemical user who wants cheaper chemicals, the chemical manufacturer who requires improved apparatus, and so on. But the industrial consumer is not organised centrally like the Government, nor, indeed, is he quite so well off. Furthermore, in some regions of industry, he does not realise the need for research and development: finally, there is a feeling that he is apt to ignore opportunities for developing invention.

This last possibility led the Government in 1949 to create the National Research Development Corporation, which, by developing inventions to the prototype stage, represents an interesting example of the Government working across the whole width of the spectrum. There are, indeed, other examples of the Government doing this: the Post Office, which represents the Government in a consumer role, places development contracts with industry for the apparatus it needs, and in the development of atomic energy for civil purposes the Government has assumed the responsibility.

In fact, it can probably be said that in the civilian field, the Government may assume the responsibility for development in fields where it is a consumer and in fields where the national interest is unequivocally involved as in atomic energy. It is interesting, too, to note that the Advisory Council on Scientific Policy, the Government's senior advisory body on the civil side of research, recommended in its 1953 annual report extension of the policy of the Government placing development contracts with industry, particularly for projects of long-term character.

In one field, the Government has already been led to do this anyway—the field of fuel and power.

By the Ministry of Fuel and Power Act of 1945, the Minister is "charged with the general duty of securing the effective and co-ordinated development of coal, petroleum, and other minerals and sources of fuels and power in Great Britain, of maintaining and improving the safety, health and welfare of persons employed in, or about, mines and quarries therein, and of promoting economy and efficiency in the supply, distribution, use and consumption of fuel and power, whether produced in Great Britain or not."

The analysis of these wide responsibilities, and those laid directly on the nationalised fuel and power industries in the Acts creating them, lead in the case of research and development to organisations under the nationalised industries concerned with the problems of supply and distribution which are their main responsibilities, and to organisations under the Minister, who co-ordinates the whole pattern, concerned not only with safety and health research, but with research and development in the efficient "use and consumption of fuel and power," and in matters of longer term or more general character than is appropriate to the individual nationalised industries.

Whatever the basis on which Government finances research and development leading to a new machine or product, however, in cases where the Government is not the consumer, the subsequent steps of manufacture and operation are clearly matters for industry itself.

Defining Objectives

At the violet end of the spectrum we feel that the number and kind of new products should be fixed by demand. In the defence field it is. The Services appear to know what they want. The Government appears to know what it can afford to spend on these wants. The objectives are consequently defined and the

fundamental researches and inventions appropriate are applied, new researches resulting from the right-to-left approach are put in hand, and a perfectly logical scheme of research and development is planned.

Looking at civil industry one does not see this orderly picture and one knows that there is something wrong. We can see the full spectrum shining evenly on a small scale in particular organisations but civil industry at large does not exhibit it. The truth is, of course, that whilst the large units in an industry can create satisfactory research and development organisations, the small ones cannot afford to.

Private industry has a horror of centralisations. Will it be able to indulge that horror much longer ? Collaboration appears to be essential. It is, however, admittedly difficult because in achieving it the essential intimacy of the individual firms with the research and development processes must be maintained. The attempts at collaborative research through the industrial research associations are only partially successful and, if they are to grow to include genuine development and if they are going to get closer to the industries they serve, a new deal amongst their industrial sponsors is needed.

Laissez-faire and Improvisation

There is, regrettably, a strong tendency in a large section of British industry to let things slide. A firm finds it can prosper by making the same old thing over and over again. It can see itself prospering in the same way next year, and perhaps even in five years' time. Ten years hence is too far away to bother about anyhow. This seems to me a poor philosophy but admittedly it is not necessarily disastrous because we have in this country a great gift for improvisation. That gift has saved more than one organisation which did not deserve to be saved. Improvisation is an art which we must use to the full but not abuse. The firm with no thought for the future must be taught to plan ahead : the gifts of improvisation must be properly used in the business of development. To neglect to plan for the future and then to save the situation by a major improvisation is an expensive policy. The cost to the country of the material damage done by atmospheric pollution is vastly greater than the cost of preventing the trouble developing. We have known for many years what was happening through pollution of the atmosphere and we have stood by watching it go on. Costly improvisation like the £1,000,000 rehabilitation of Westminster Abbey is always going on. Fortunately, the possibility of basic remedy is now also being examined—but for other reasons.

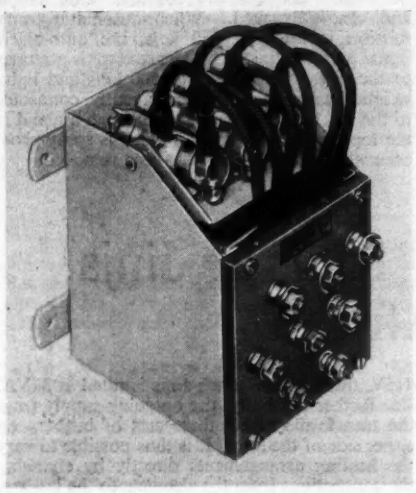
But improvisation in the sense of *ad hoc* changes to effect improvements is the essence of engineering development. In this sense we do well. The history of a great aeroplane like the "Spitfire" is improvisation of this kind. The history of a great engine like the "Merlin," the first of which was 850 h.p. and the last of which, looking much the same, was 2000 h.p., is another example. Basically the problem is to know when to improvise. Improvisation should not be the last step in a policy of *laissez-faire*. It should be the creation of a new thing by the minimum adaptation of another.

Summing-up

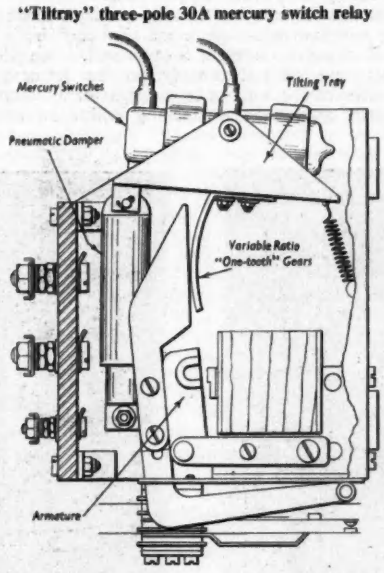
The burden of this lecture has been the advocacy of more research and development aimed at utilitarian objectives. I have not said how much more, and indeed I believe that that must depend to a great extent upon engineers in all kinds of enterprises, private, nationalised and Governmental, clearly seeing what the future demands and having the persistence and persuasiveness to see that the future gets it. This means not only that they must seek to find better ways of doing to-morrow what they are doing to-day, but that they must not be afraid to define the broader consummations which would benefit their fellows and the engineering courses to achieve them. It is in the struggles for great objectives that great work is done.

Mercury Switch Relay

We have received some particulars of a tilting mercury switch relay, developed and made by Besson and Robinson, Ltd., 6, Government Buildings, Kidbrooke Park Road, London, S.E.3. The tilting mechanism of this relay is designed to give smooth movement with the object of prolonging its life and allowing inductive loads to be switched safely, irrespective of supply voltage variations up to ±30 per cent.



"Tiltray" three-pole 30A mercury switch relay



Principle of "Tiltray" mercury switch relay

The equipment, which is known as the "Tiltray" mercury switch relay, is illustrated above. It consists, essentially, of a bank of mercury switches mounted on a tilting platform which is centrally pivoted, as shown in the drawing. Tilting of the platform is effected by a relay coil and armature through the medium of a mechanism which can be regarded as a cam and follower or a pair of single-tooth variable-ratio gears. The "teeth" are so profiled that the "gear ratio" falls rapidly as the armature accelerates towards the coil. Accordingly, the tray carrying the mercury switches is brought smoothly to rest and this effect is assisted by the pneumatic damper.

This method of smoothing the movement allows the use of a coil which is stated to be strong enough to operate the relay, even with a voltage 30 per cent below normal ; on the other hand, the smoothing removes the risk of damage to the switches by over-violent movement, if the voltage should rise above normal. The relay chassis used is the company's type "C" assembly, which is designed for silent operation on alternating current with a coil consumption of 5VA to 15VA ; on direct current the consumption is 2W.

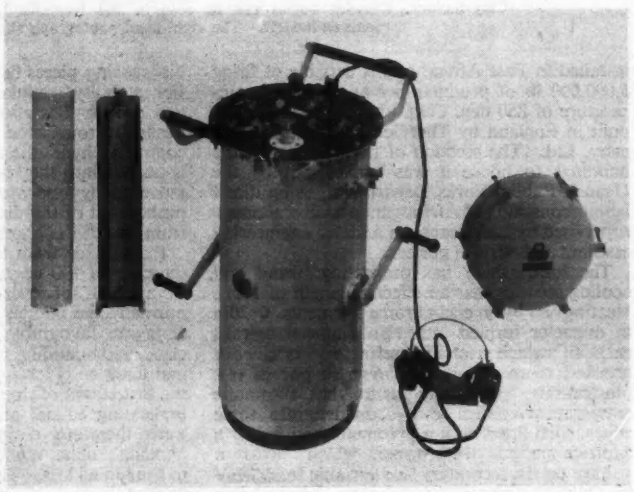
Materials and finishes are fully tropicalised to comply with the requirements of Inter-Services Specification RCS/1000 ; the coils are wound on nylon-loaded moulded bobbins, paper interleaved and vacuum impregnated. On each relay the insulation is tested at 2000V. The armature and the tray are pivoted on stainless steel shafts with "Oilite" bearings.

The "Tiltray" relay is suitable for operation from any supply up to 500V, d.c. or a.c., and the maximum switching capacity is 3 pole, 60A.

Portable Lifeboat Radio

A new portable radio transmitter and receiver for use in ships' lifeboats is now being produced by the Marconi International Marine Communication Company, Ltd. Known as the "Salvita," it is completely self-contained, watertight and will float after having been thrown into the sea from the deck of a ship in distress. The "Salvita" has been developed from earlier sets designed by the company ; it meets the requirements of the latest G.P.O. specification for this form of equipment, and, we are told, has undergone tests simulating the worst conditions likely to be encountered at sea. These tests included being continuously shaken on a special vibrating table, followed by a bump test consisting of 500 bumps at the rate of one per second with a free drop of 1in. In addition, after spending ten hours in a temperature of 70 deg. Cent. under dry-heat conditions, the set was operated for two hours at 55 deg. Cent. A period was spent in damp heat of 40 deg. Cent. with a relative humidity of 95 per cent, and the next test was followed by some hours at a temperature of minus 25 deg. Cent. Further tests consisted of exposure to high-pressure water spraying, immersion in water, corrosion tests after salt-water spraying, and an examination for mould growth after treatment with an aqueous solution of mould spores and subsequent incubation. In a final experiment the set was thrown from a height of 30ft into water, and operated at full efficiency after it had surfaced and been recovered.

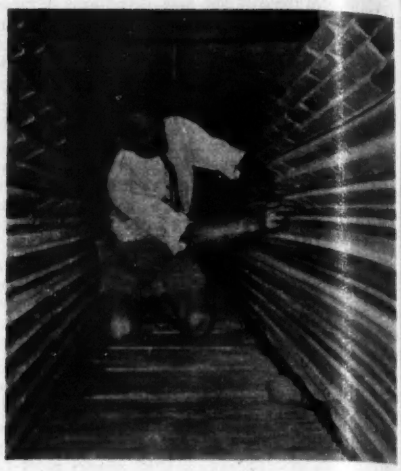
The "Salvita," shown in our illustration, is housed in a cylindrical case fitted with carrying handles. It is a little over 2ft in height, and is painted bright yellow for easy recognition in



"Salvita" portable lifeboat equipment showing set opened up ready for operation

water. In the upper portion of the case is a medium and short-wave transmitter and medium-wave receiver, all the operating controls being placed on the circular top panel and covered by a watertight lid when not in use. Batteries are dispensed with, all the power for transmission and reception being supplied by a hand generator which occupies the lower portion of the case. The generator shaft protrudes through watertight glands and is rotated by two handles which fold flat against the case and are protected by detachable covers, which serve as sinkers for the earth wire. The aerial can be of the telescopic rod pattern, or of wire rigged on the lifeboat's mast or suspended from a kite or balloon.

The transmitter, which is crystal controlled, can be switched to either 500 kc/s or 8364 kc/s. A hand key is fitted, but automatic transmission of the SOS signal, followed by a long dash for direction-finding purposes, is also provided so that the " Salvita " can be operated by untrained personnel, the necessary controls being simple and clearly marked. When automatic transmission is used on 500 kc/s, the auto-alarm signal precedes the SOS. The receiver is pretuned to the distress frequency of 500 kc/s and lightweight headphones are permanently connected to the set, the cable being led through a gland in the top panel. The control panel is spray-proof even when the top cover has been removed.



Examining the spiral heating elements in the 100ft tunnel kiln

Electric Tunnel Kiln at Jinja, East Africa

ONE of the difficulties that faces the Protectorate of Uganda in its housing programme is that many building materials have to be imported and carried 750 miles from Mombasa, the nearest port. To meet the demand for cheap and speedy building, particularly in Kampala, Jinja and Entebbe, the Uganda Public Works Department therefore decided to make its own tiles and cellular blocks and an electric kiln was erected at Jinja, where there is a good supply of suitable clay as well as adequate power from the Owen Falls Hydro-Electric Scheme.

It is the first all-electric tunnel kiln to be installed in East Africa, and is capable of firing 5,000,000 lb of products per annum, at a temperature of 850 deg. Cent. It was designed and built in England by The General Electric Company, Ltd. The erection of the kiln and of the buildings to house it was carried out by the Uganda Public Works Department, using direct labour consisting of African and Asian craftsmen supervised by Europeans, an African engineering assistant and African porters.

The kiln, which has preheating, firing and cooling sections, has an effective length of 100ft. Heating is by nickel-chrome elements 0·20in in diameter formed into 1¼in diameter spirals, each of which rests in refractory brickwork grooved to receive it, as shown in one of our illustrations. The firing section has automatic temperature control and is divided into three zones, each fitted with a pyrometer and fed by a Scott-connected transformer, which gives a voltage on the secondary side variable from 103V to 126V, two phase, the incoming voltage being 415V, three phase. Each zone is rated at 3kVA. For further flexibility, the outgoing supply from the transformers feeds three sets of busbars on either side of the kiln. It is thus possible to vary the heating arrangements directly by changing the connections from the elements to the busbars by means of specially shaped links.

Bogies for carrying the clay products through the kiln have side-angle runners which move in a sand trough to effect a furnace seal. The products are stacked directly on the refractory hearths of the wagons to a height of 3ft above hearth level with a stacking width of 18in. No spacing pieces between wares are necessary. For stability, cellular blocks are stacked first and roofing tiles above them. The wagons are pushed through the kiln by an automatically controlled hydraulic ram. When a fresh wagon is pushed into the kiln all the preceding wagons move along one space and a fired wagon is pushed out of the discharge end, as can be seen from one of the photographs reproduced here.

Exhaust air from the kiln is used to pre-heat the clay to 100 deg. Cent., to prevent cracking as a result of over-rapid heating. Although normally the midday atmospheric conditions at Jinja are favourable to the efficient drying of clay, the humidity rises considerably at night and tends to crack products which have reached the last stages of drying. A heat recuperator, a preheating tunnel and batch drying chambers were therefore designed and erected by the Uganda Public Works Department in addition to the tunnel kiln. The recuperator was included so that the flow of air in the tunnel kiln could be reduced to the minimum required for efficient firing, thus reducing the amount of heat taken away by the exhaust air.

A trial test, without the recuperator using the minimum quantity of air necessary for the efficient firing of the ware in the kiln, showed that exhaust air taken straight from the kiln into the preheating tunnel contained excessive moisture. This condensed on the products in the lower, cooler parts of the preheating tunnel and cracked the clay, causing stacks to collapse later when they were passing through the kiln. The wet air from the kiln is therefore used in the recuperator to heat fresh air which is blown into the preheating tunnel and from there into the batch drying chambers, where it passes into the atmosphere before reaching its saturation temperature.

Clay factory. Unladen bogies can be seen in the foreground, with the preheating tunnel in the background, and the batch drying rooms on the left. The right-hand photograph shows fired products being discharged from the tunnel kiln

One of our illustrations gives a general view of the factory showing, on the right, part of the discharge end of the tunnel kiln. In the foreground are bogies ready to be loaded with cellular blocks for transport to the preheating tunnel in the centre background. On the left of the illustration are the batch drying rooms, which are connected by trunking with the preheating tunnel.

Another illustration shows a loaded bogie of fired products being discharged from the tunnel kiln. The upper photograph reproduced here shows an engineer examining the spiral elements in the firing section of the 100ft long tunnel kiln.

Safety Factor in the Design of Seamless Steel Gas Cylinders*

By S. E. MITCHELL

In the following discussion, based on papers presented to the Home Office Gas Cylinders and Containers Committee (1946) and the British Standards Institution Secretariat Panel (I.S.O.) on Gas Cylinders, the author outlines the application of the safety factor in the design of seamless steel gas cylinders and suggests a possible unification of the diverse methods now in use. The first part describes the methods and the arguments in their favour ; the second part proposes a common basis for deriving working stress.

Outline of Present Practice

The Function of the Safety Factor.—The design of a gas cylinder is based on limited data bearing a relation to some of the more obvious influences to which it will be subjected in the course of service. Separate allowances are usually made for corrosion and for external loading (e.g. due to storing the cylinders in piles). Corrosion is generally allowed for by an extra thickness added to that required for other purposes, and external loading by a limiting minimum thickness.

Apart from these allowances, the wall thickness is calculated from a permissible stress figure. Some designers maintain that this stress should be set at a given fraction of the yield stress of the material used ; others that the stress calculated at the hydraulic test pressure (equal to some given multiple of the maximum working pressure) should not exceed a certain value ; and others that the stress should be set at a given fraction of the tensile strength of the material used.

A safety factor represents an attempt to allow in terms of a practical testing technique for a very large number of unpredictable variations in service conditions. Besides simple stress, these may include small deformations ; various combinations of stress and strain ; impacts ; vibration and temperature changes which may cause fluctuations of stress ; manufacturing variations in dimensions; and, perhaps, varying degrees of misuse depending upon the intelligence and scrupulousness of the user. No single property determined by mechanical test is an infallible index of the behaviour of the cylinder in service. It is not imagined, because the calculated working stress in the wall of a cylinder is required not to exceed, say, one-third of the tensile strength, that service conditions will be liable at the worst to induce a stress of three times the calculated working stress, and to make no other demands on the cylinder. The test which is to serve as the basis for applying a factor of safety should therefore be the one that is the best index of the general resistant qualities of the material.

Gas cylinders can be divided into two classes. The first class comprises cylinders for permanent and high-pressure liquefiable gases. They are nearly always operated at a comparatively high internal pressure and normally the wall thickness needed to resist this pressure will make the cylinder stout enough for all ordinary loading and handling.

The second class comprises cylinders for low-pressure liquefiable gases. In these resistance to external loads and handling acquires greater relative importance and the manufacture of cylinders which are very thin in relation to their diameter may be impracticable. The necessary wall thickness is governed by these factors rather than by the internal pressure.

Working Stress Related to Yield Stress.—A constant factor of safety applied to the yield stress finds favour in some quarters. By this method very light cylinders can be designed in alloy steels and light alloys, treated to raise the yield stress to a high value. The yield stress. may, indeed, be very close to the tensile strength

The term " yield stress " is used loosely and in materials that do not show the yield phenomenon of mild steel denotes a proof stress corresponding to 0·2 per cent, or some other small percentage, of permanent strain.

Materials with the high proof stress may, however, save little or no weight in cylinders for low-pressure liquefiable gases, where, as explained above, the minimum practicable thickness depends largely on rigidity and manufacturing limitations.

Working Stress Related to Hydraulic Test Pressure.—When cylinders are designed to a stress calculated at the hydraulic test pressure, and when this pressure is a simple multiple of the working pressure, there is no difference in principle from designing to the stress at the working pressure. The factor of safety is still applied to the yield (or proof) stress, or to the tensile strength, as the case may be.

The hydraulic test pressure is, however, not always made a simple multiple of the working pressure. A value of one and a half or two times the working pressure does not provide a very searching test on cylinders for low-pressure liquefiable gases, and the stringency of the test varies with the working pressure and with the diameter of the cylinder. For this reason a hydraulic test pressure is often advocated which will induce in the wall of the cylinder a stress not far short of the yield stress. This test pressure is calculated on the design wall thickness of the cylinder, and the test is carried out as a stretch test—i.e. the permanent expansion of the cylinder is observed. Excessive permanent expansion indicates some deficiency, such as insufficient wall thickness, in the cylinder.

Where the hydraulic test pressure is chosen in this way to give a stress approaching the yield stress and not directly related to the stress at the normal working pressure, it is not usually employed as a design factor—probably because internal pressure of any kind is not, in this case, of primary importance in design.

For cylinders for permanent and high-pressure liquefiable gases the hydraulic test pressure can be expressed as a multiple of the working pressure and still, in actual fact, induce a stress in the cylinder wall approaching the yield stress of the material. Here, if the design formula includes the stress at the test pressure, the yield stress is the implied criterion.

In cylinders made from materials of high yield strength, the pressure required to apply a stress approaching the yield may be beyond the range of commonly available apparatus, and a lower test pressure is sometimes adopted as a matter of expediency. In such circumstances, even if the design formula included the stress at the test pressure, the factor of safety would not necessarily be applied to the yield stress. The test pressure would be, in effect, arbitrarily chosen, and by the inclusion of a suitable multiplying factor in the design formula the working stress could be related to either the yield stress or the tensile strength.

Working Stress Related to Tensile Strength.—A factor of safety applied to the tensile strength is regarded by its advocates as the best practical means of relating the design of the cylinder to the general resistant qualities of the material used. It is true that a material might have a very high tensile strength and yet be very brittle, but common sense precautions, such as the stipulation of a minimum elongation in the tensile test, are assumed.

In view of this, the " factor of safety " applied to the proof (" yield ") stress in a material in which this proof stress is close to the tensile strength is regarded as somewhat artificial ; for the factor of safety on the tensile strength is in that case very little more than the factor of safety on the proof stress, whereas in mild steel it may be nearly twice the factor of safety on the yield stress. Moreover, an increased proof stress in any material may be accompanied by a decreased impact resistance. Experience has shown, also, that with alloy steels and light alloys an increased proof stress is not necessarily accompanied by an increased fatigue resistance, and therefore does not always justify a higher working stress.

Proposals for a Common Basis

The values of working stress in the design of gas cylinders differ to some extent in different countries and for different materials of construction. The present discussion assumes the following formula for the calculation of wall thickness :—

$t = pd/(2s-p)$, with a minimum thickness of $0.027\sqrt{d}$,

where

t = minimum wall thickness (inch) at any point ;
p = internal working pressure (pounds per square inch) ;
d = inside diameter (inch) of cylinder ;
s = maximum permissible stress (pounds per square inch) in cylinder wall at working pressure.

It is proposed that for seamless steel gas cylinders the value of s in this formula shall be some given fraction of the tensile strength of the steel. The ratio of working stress to tensile strength is in the neighbourhood of one-third in many specifications ; in other words, the safety factor on the tensile strength is about 3.

A working stress of one-third of the minimum

Table *—*Working Stress in Seamless Steel Cylinders for Permanent Gases Permitted in Various Countries*

Country	Steel	Maximum allowable working stress / Tensile strength
U.S.A. and Canada: Working pressure up to 900 lb per square inch	Spec. 3A and 3AA	$\frac{S_p}{T.S.} = \frac{14{,}400}{T.S. \text{ in lb/sq. in}}$ ($\frac{s}{T.S.}$ = a higher value —see text†)
U.S.A. and Canada: Working pressure over 900 lb per square inch	Spec. 3AA	$\frac{S_p}{T.S.} = 0{\cdot}4$, but max. $S = 42{,}000$ lb/sq. in ($\frac{s}{T.S.}$ and corresponding over-ruling maximum are higher—see text‡)
France	All normally permitted varieties	0·33
Belgium	Carbon	0·3 to 0·375
	Alloy	0·45
Switzerland (internal traffic)	Carbon	0·325
	Alloy	0·4
Switzerland (international traffic)	Carbon	0·29
	Alloy	0·36
Germany	All normally permitted varieties	0·31
South Africa	Low carbon	0·37
	High carbon... ...	0·265
	Manganese	0·41
	Alloy	0·42
Great Britain... ...	B.S. 400 (low carbon)	0·32
	B.S. 399 (high carbon)	0·30
	B.S. 1045 (manganese)	0·34

* The values in the table are based on information collected by Messrs. F. S. Marsh and C. Twigg, of the Chesterfield Tube Company, Ltd. S_p denotes the working stress, calculated by putting $P = p$, and not the stress at the test pressure specified in the American and Canadian regulations.

† The highest value of $s/T.S.$ in practice would probably be 0·38, when $s/S_p = 1{\cdot}17$ and tensile strength = 44,800 lb per square inch (20 tons per square inch).

‡ The highest value of $s/T.S.$ in practice would be 0·47, when $s/S_p = 1{\cdot}17$; but s cannot exceed 49,100 lb per square inch (22 tons per square inch).

* Communication from the Mechanical Engineering Research Laboratory.

of the range of tensile strength specified for the steel used is now proposed as a normal maximum in seamless gas cylinders. For certain steels, however, a higher ratio of working stress to tensile strength might be permissible if it were shown by experience to be justified.

Relation of Proposals to Present Practice.—Apart from special modifications to cover external loading, the formulæ at present in use for relating internal pressure to stress in the wall are of two main kinds. One is fundamentally the same as that given above, though the minimum thickness requirement may differ. The other, prescribed in the American and Canadian regulations, is :—

$S_P = P(1{\cdot}3D^3 + 0{\cdot}4d^3)/(D^3 - d^3)$, where
P = internal pressure (pounds per square inch) ;
S_P = stress (pounds per square inch) in cylinder wall at pressure P ;
D = outside diameter (inch) of cylinder ;
d = inside diameter (inch) of cylinder.

This formula is based on the now discredited maximum principal strain criterion of elastic failure : S_P is not an actual stress, but is the tensile stress which acting alone would give the same maximum principal strain as that in a cylinder of the given dimensions under the given pressure. The ratio s/S_P depends on the ratio of thickness to diameter ; it is equal to 1·17 when the ratio of thickness to diameter is negligible, and decreases as this ratio increases, becoming, for instance, 1·04 when thickness/diameter = 1/10.

The table on page 99 shows the working stress permitted in various countries. The stress has been expressed in terms of the tensile strength (*T.S.*) of the material of construction.

If a stress at design pressure of one-third of the tensile strength were adopted in cylinders for certain high-pressure liquefiable gases, some of the present test pressures would require modification to avoid producing a stress above, or too closely approaching, the minimum stipulated yield point in some steels.

For cylinders for low-pressure liquefiable gases, which can be taken as having a design pressure not greater than 500 lb per square inch, the over-ruling minimum requirement (t not less than $0{\cdot}027\sqrt{d}$) will operate for all values of d which are practical for seamless cylinders, i.e. values of d not greater than 12in. If a fixed test pressure is specified for any given liquefiable gas, as it is in several countries, the stress at the test pressure varies with d, and under certain conditions might exceed the minimum yield of the material.

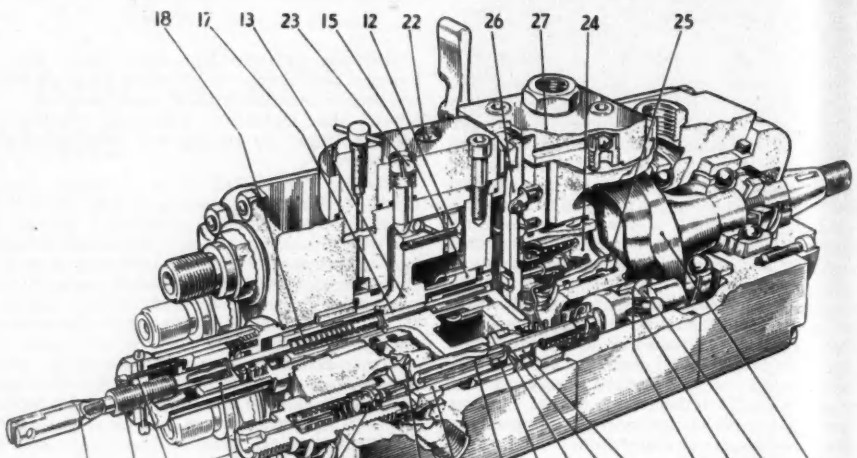
A uniform value of not more than one-third for the ratio of working stress to tensile strength could therefore only apply to cylinders for liquefiable gases if test pressures were calculated, according to the material and dimensions of cylinders, to produce some prescribed stress.

The work described was carried out in the Mechanics and Materials Division of the Mechanical Engineering Research Laboratory as part of the research programme of the Mechanical Engineering Research Board. It is published by permission of the Director of the Laboratory.

Rotary Fuel Injection Pump

A FUEL injection pump, which is a complete departure from conventional practice, has been designed and built by Mono-Cam, Ltd., and the unit is compact and of sturdy construction. The pump, illustrated herewith, is of constant-stroke, variable-delivery pattern, there being one pumping element for each cylinder. It is available in two sizes, each of which is produced for use with four or six-cylinder engines. quiet combustion, particularly when idling and over the low-speed range.

Instead of the more conventional long multi-throw camshaft, the pump has a rotary cam with a single lobe face, so that the stroke of the individual plungers is identical. The profile of the cam face is designed to give the best injection characteristics for normal requirements, but special shapes can be provided to suit particular



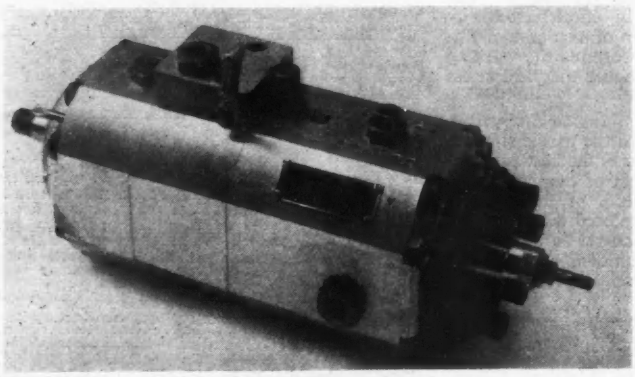
1—Face cam.
2—Cam rollers.
3—Needle roller bearings.
4—Thrust washers.
5—Element barrel.
6—Element plunger.
7—Element control sleeve.
8—Port holes.
9—Groove.
10—Centre hole.
11—Cross holes.
12—Control sleeve plate housing.
13—Control shaft.
14—Delivery valves.
15—Enlarged stem of control shaft.
16—Speed control rack.
17—Flow restriction.
18—Governor spring.
19—Idling stop.
20—Maximum speed stop.
21—Idling stop adjusting screw.
22—Idling damper adjusting screw.
23—Maximum fuel delivery adjusting screw.
24—Feed pump plunger.
25—Plunger sleeve.
26—Plunger operating lever.
27—Valve housing.

General arrangement of rotary fuel injection pump

Elements of 5mm to 7mm diameter are fitted to type " A," while type " B " has elements of 7mm to 10mm diameter.

This pump has been evolved over a period of years and development work was completed in 1951, after which the pump was subjected to tests in the research laboratory of one of the major oil companies. In addition, several units have been undergoing service proving trials, and a number of the pumps, having the correct cam lift and element size for a particular engine, are now in regular service on vehicles belonging to several public service transport undertakings. We were able recently to make a trial run in a public transport vehicle fitted with a Mono-Cam injection pump, and noted the smooth and combustion chambers. A large diameter thrust race supports the camshaft and the cam face is carried on ball bearings so that complete rigidity is achieved and freedom from the bending deflections encountered in an " in-line " fuel pump. There is a bevel on the cam face, designed to prevent slipping between the cam and the tappet roller, which is case hardened and ground to the same bevel as the cam. Needle roller bearings carry the roller, and the radial thrust on the tappet is taken by a liberal bearing surface.

The tappets impart motion to the pumping elements which have no helix, so that one of the main causes of wear is removed and also loss of balance. Three parts form the element,



Rotary fuel injection pump

Pump components

namely barrel, plunger and sleeve, and the cut-off is instantaneous, as the whole of the circumferential groove in the plunger is uncovered simultaneously. This arrangement reduces injector "dribble" and also carbonisation, so that injector maintenance is reduced. A distinct pilot injection effect is achieved at a camshaft speed of 400 r.p.m. and, although not maintained over the whole speed range, the initial low injection rate remains a characteristic throughout and considerably reduces "diesel knock." Pressure release pattern delivery valves, having flat seatings to ensure rapid and regular action, are fitted. Forming an integral part of the injection pump is the fuel lift pump, which consists of an aluminium alloy piston working in a steel sleeve carried in the centre of the roller tappet housing. This piston is actuated by a lever and a small roller carrier from the main cam.

Governing is by either hydraulic or by combined pneumatic and hydraulic means. With hydraulic governing the pressure built up by the "spill" of the pumping elements is the controlling force. With the combined system high-speed control is by hydraulic means, while at idling speeds pneumatic control comes into operation. The design of the pump permits horizontal or vertical mounting and the mounting radius is standard, so that the new pump is interchangeable with the existing fuel injection equipment. Again the pump is totally enclosed, so that it is less likely to suffer from operational maltreatment and is both dustproof and waterproof.

With either form of governing and including a fuel lift pump "A" type pumps weigh 13½ lb and are 8in in length by 3¼in. diameter, while the "B" type unit has a diameter of 4¼in, measures 10¼in in length, and weighs 17½ lb, which compares with an approximate weight of 46 lb for the equivalent "in-line" pump. We include an exploded view of the pump components and a line drawing of the pump.

Pump Operation

The engine drive is transmitted through an adjustable coupling to the bevelled rotary cam, on which run the case-hardened rollers which give motion to the tappets and so actuate the pump elements. Injection begins when the plunger covers the portholes in the barrel and ends when the motion of the plunger causes the circumferential groove to leave the control sleeve and so allow the oil to escape through the centre hole and cross hole. The control sleeves are housed in a circular plate mounted on a control shaft to which the governing devices impart axial motion to vary the delivery of fuel.

For hydraulic governing the necessary pressure is created from the "spill" of the pumping elements by restricting its return to the feed side of the pump, and the pressure acts on the control shaft stem. Speed control is by actuation of the control rack, which alters the restriction to the flow and the tension of the governor spring. An idling stop and a maximum speed stop limit the movement of the control rack. There is a screw for adjusting the idling stop and another for adjusting the idling damper, and a third for setting the maximum fuel delivery. When arranged for combined pneumatic and hydraulic governing there is a flexible diaphragm attached to the control shaft and to the interior of the pump housing to form a sealed off unit, the inside of which is connected to the butterfly valve in the engine air intake manifold. The outside of the diaphragm is subjected to the "spill" oil pressure as the further return of this "spill" to the feed side is restricted by a pin. This pressure, a function of speed and load, gives accurate control at high speeds while idling is controlled by the pneumatic means.

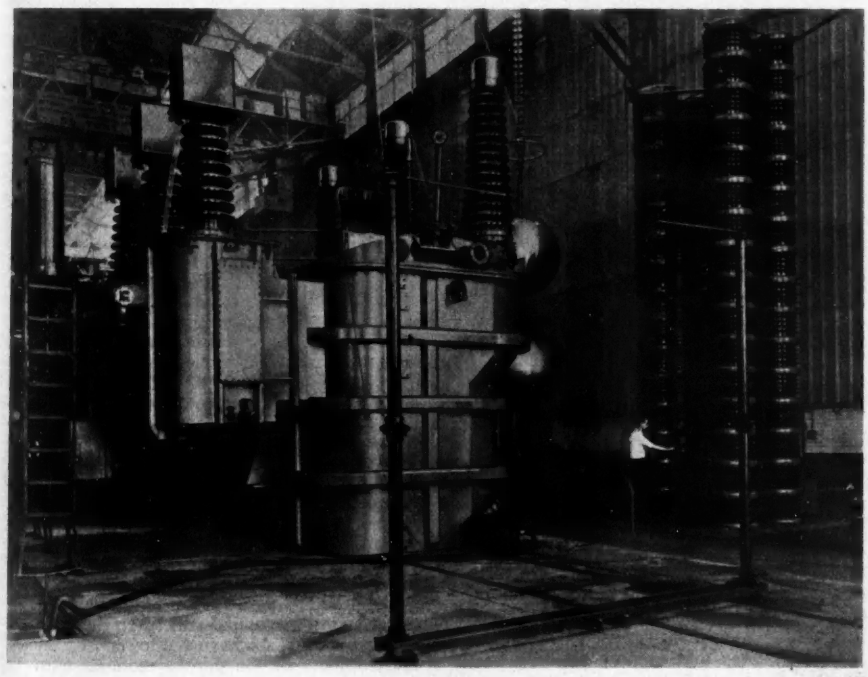
Impulse Tests on 275kV Power Transformer

Our illustration shows a 120MVA, 275kV, three-phase auto-transformer undergoing impulse tests in the Trafford Park works of Metropolitan-Vickers Electrical Company, Ltd., Manchester, 17. This transformer is the first of eight similar equipments that are being made by the company for the British Electricity Authority's 275kV grid. Each transformer is designed for a voltage ratio of 132/275kV with on-load tap changers at the 132kV terminals to give a voltage variation of ±15 per cent in eighteen steps.

Before the first of these transformers, complete with on-load tap changers, was despatched from the works recently, it was subjected to impulse withstand tests in the presence of representatives of the British Electricity Authority, Messrs. Merz and McLellan and Messrs. Kennedy and Donkin. For these tests the impulse voltage withstand levels, based on a 1/50 microsecond wave, were 1050kV for the 275kV winding and 550kV for the 132kV winding; the tappings and tap changers, being at the 132kV point, were subjected to the full impulse voltage.

The sequence of the tests, which were applied to the 275kV and 132kV terminals in turn, was: first, a calibration shot, followed in turn by a 100 per cent full-wave shot, two 115 per cent full-wave shots, and two 100 per cent full-wave shots.

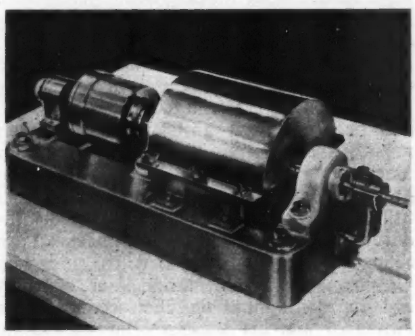
We learn that the tests took place in a recently completed extension to the company's transformer factory at Trafford Park and that they were the first tests to be carried out on a 275kV auto-transformer complete with tap changers.



120MVA, 132/275kV three-phase auto-transformer with on-load tap changers undergoing impulse tests

Small Continuous Centrifugal Separator

Some years ago Sharples Centrifuges, Ltd., Woodchester, Glos, introduced its "Super-D-Canter," which is used for the recovery of solids from slurries and the classification of solid particles according to particle size. This machine discharges the separated liquid and solids continuously and it can operate with a feed rate from 300 to 2500 gallons per hour according to the application. A new machine of this design, but of much smaller capacity, has now been introduced for simulation tests with pilot plant, laboratory use or for small-scale production operation.



Continuous centrifugal separating machine with a normal operating speed of 4000 r.p.m. and feed capacity of 1 gallon per minute

The new machine, illustrated herewith, has an average feed capacity of 1 g.p.m. and a maximum feed rate of up to 2½ g.p.m., the actual capacity varying with the particle size distribution of the solids and the nature of the liquid in which they are suspended. In the machine a horizontal shaft driven by a vee belt carries a conical bowl within which is mounted a screw conveyor. This conveyor is driven through a gearbox on the bowl hub at a lower speed than the bowl. Liquid from which the suspensions are to be removed is fed into the bowl through an axial feed tube.

In operation centrifugal force separates liquid from the slurry, and the liquid flows out of the bowl through apertures in what is known as the plate dam. The separated solid matter is moved along the bowl to the opposite end by the screw conveyor and discharged through ports into the casing. From the casing the solids flow in a continuous stream from one end, and the liquid from the other end.

The normal operating speed of the machine is 4000 r.p.m., but, if desired, it can be operated at speeds up to 6000 r.p.m.

M.O.S. Inspection of Copper Base Alloy Castings.—It is announced that the Ministry of Supply and the Association of Bronze and Brass Founders have recently agreed on the terms of "A Code of Procedure to Facilitate the Co-ordination of Inspection for Copper Base Alloy Castings Ordered by the Ministry of Supply." The inspection procedure set out in the code, which will come into force on September 1, 1954, will apply to all Ministry of Supply contracts and the sub-contracts arising from them, for copper base alloy castings. Not only founders, but all Ministry contractors and sub-contractors, will require copies of the code, which is now being printed and which will be available to non-members of the Association at a price of 5s. per copy post paid. Applications for the code should be made to the Association's offices, 69, Harborne Road, Edgbaston, Birmingham, 15.

The American Scene

(By Our American Editor)

POWER FROM NIAGARA FALLS

THE recent reorganisation by Governor Dewey of the New York State Power Authority has raised hopes for an early settlement of the jurisdictional dispute over the development of additional hydro-electric generating capacity at Niagara Falls. Two points are at issue in the controversy which is now before Congress for resolution. The first is : should the additional energy be developed by a public agency, such as the State Power Authority, or should the water power resources be turned over to privately owned and operated utility companies ? The second is : how should the power be distributed once it has been generated ? Republicans in New York State are sharply divided on the first question ; Governor Dewey and his associates who are in command of the State party organisation favour the development by the State Power Authority. Another influential group, which includes most of the members of Congress from New York, favours permitting the Niagara-Mohawk Power Company and four other utilities associated with it to undertake the development. The Democrats in New York State generally are inclined to side with Governor Dewey on the first issue, but they disagree with him on the second. The Governor and his associates favour feeding the power to be generated at Niagara Falls into a large grid along with the power developed at privately-owned electricity plants and the power to be produced by the State Power Authority from the International Rapids section of the St. Lawrence River. Because all of the power transmission lines required would be interconnected in a grid system, this would make the benefits of Niagara Falls hydro-electric power available over a wider area than otherwise would be possible. However, the Democrats maintain that such a mixing of public and private power would dissipate a number of the potential advantages to consumers of public power development. They want the State Power Authority to build its own transmission lines, to make certain that municipally-owned and co-operative electricity distributing systems get a preference in the purchase of public power. In this way, they contend, the rates charged for public power could serve as a yardstick to measure the fairness of the prices which will be charged for privately developed power by the utility companies.

The present dispute over who should develop additional generating facilities at Niagara Falls started in 1950, when the United States and Canada concluded a treaty that gave each country the right to take enough additional water out of the river above the falls to produce an equal amount of electrical energy for each. When the United States Senate ratified the treaty it attached a rider reserving to Congress the right to designate the agency to develop the American share of this additional water power. Without the rider, the choice of the American agency would have been left to the Federal Power Commission, which recently designated the State Power Authority as the agency to develop the hydro-electric power potential of the St. Lawrence Seaway scheme. Canada imposed no similar restrictions on the selection of its agency. As a result it has been able to go ahead with the physical construction necessary to produce electrical energy from Niagara water. On the Canadian side already a large intake has been installed in the river above the falls and large channels constructed to carry the diverted water downstream below the falls, where it will be used to turn the turbines.

The 1950 treaty between the United States and Canada was a modification of a 1909 pact which barred either nation from diverting any more water from the Niagara River without the consent of the other. At the time the 1909 treaty went into effect, Canada was already diverting more water than the United States. This disparity has continued to date and will continue after the new works are built. Indeed, it could be increased temporarily if Congress failed to act in the present dispute. A clause in the 1950 treaty provides that either nation can use the other's share of Niagara water, as well as its own, if the other fails to utilise the amount assigned to it. At present Canada has generating plants, powered by Niagara water, which have a capacity of 840MW. On the American side there are privately-owned plants which now generate 445MW of electrical energy. Substantially the same physical plant will be needed whether the American share of the Niagara potential is publicly or privately developed. It calls for the construction of a large intake above the falls and the construction of penstocks in the rock cliff along the gorge to carry the diverted water 5 or 6 miles downstream to Lewiston, where the power generation works would be situated. Tentative plans for the plant have already been developed by the U.S. Army Corps of Engineers, working co-operatively with engineers of the private power companies, the State Power Authority and the Federal Power Commission.

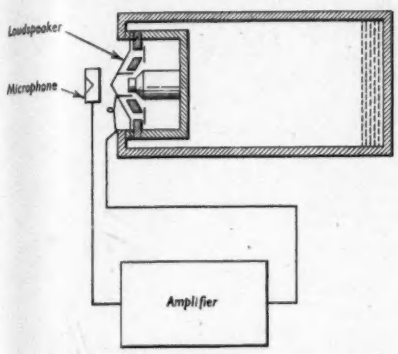
As many as four individual measures to resolve the dispute are now pending in Congress. They are the Ives-Becker Bill, sponsored by Senator Irving, M. Ives and Representative Frank Becker, both New York Republicans ; the Lehman-Roosevelt Bill, sponsored jointly by Senator Herbert H. Lehman and Representative Franklin D. Roosevelt, jun., of New York, both Democrats ; the Miller-Capehart Bill, sponsored jointly by Representative William Miller, of New York, and Senator Homer E. Capehart, of Indiana, both Republicans ; and the Case Bill, sponsored by Senator Francis Case, Republican, of South Dakota. The Ives-Becker Bill is the one favoured by Governor Dewey and the State Power Authority. It would designate the Power Authority as the American agency to undertake the development. It differs from the Lehman-Roosevelt Bill primarily in that it places no restrictions on the distribution of power once it has been developed. The Lehman-Roosevelt Bill, on the other hand, would require a preference in the sale of Niagara power to municipal plants and co-operative distributing systems. The Miller-Capehart Bill, which has already passed the House of Representatives and is now pending in the Senate Public Works Committee, would designate the Niagara-Mohawk Power Company and its associated utilities to undertake the development and to provide for the distribution of power. Finally, the Case Bill would turn the whole dispute over to the Federal Power Commission. At this stage the main political fight is between the Miller-Capehart Bill and the other three. Supporters of the Miller-Capehart Bill contend that private initiative can do a better job of developing electrical energy than any public agency. Furthermore, they argue, such a development would place no strain on public finance, but would ease the burden of other taxpayers by making a substantial annual tax contribution to the Federal, State and local governments concerned. In favour of State development it is being urged that the water power of the Niagara River belongs to all the people and, therefore, should not be handed over to any commercial group to be used to make a private profit. Those in favour of public power also point out that the users of electricity would have to pay 31,000,000 dollars less a year for public power than they would have to pay for private power. To this last claim the answer of the utilities is that the entire savings represent only the exemption from Federal, State and local taxes that would be involved. Both sides are prepared for a bitter political fight which is likely to be carried into the campaign for the congressional elections to be held this coming autumn. Thus, as happens so frequently in American politics, considerations of expediency may lead to a continued stalemate that will prevent the American use of hydro-electric power from Niagara Falls for years to come.

Electronic Sound Absorber

An interesting industrial application of electronics is being developed at the David Sarnoff Research Centre of the Radio Corporation of America at Princeton, New Jersey, in the form of an electronic sound absorber that will cope with the variety of deep noises associated with motors, the hum of conversation in a crowded hall, or even with heavy snoring. The first model has demonstrated in tests its ability to cut sound in this category by as much as 10 to 25 decibels in the vicinity of the ear. In everyday terms, this is equivalent to reducing to at least one quarter the engine noise level in the average bus, or eliminating almost entirely the steady hum of a motor-car as it is driven along at cruising speed. It is believed that, ultimately, electronic sound absorbers installed in seats aboard aircraft, buses and other vehicles that produce a deep and persistent noise may mean greater comfort for passengers. Others placed near noisy machines in factories and workshops can ease the task of the worker. Groups of such absorbers may be built into the corners of auditoriums, assembly rooms and dining-halls.

The electronic sound absorber works by turning sound waves back against themselves, and in the process it performs a task that conventional sound-proofing materials cannot handle efficiently. Present sound absorbing systems are based on the use of porous materials containing a maze of small passages in which the energy of sound waves is dissipated. Such sound-proofing works most effectively at the upper end of the sound scale. To dissipate the longer waves of sound in the lower frequencies, the thickness of the porous material must be increased. In the low frequency range of engine noise and other deep sounds, an absorbing system

based on these materials becomes too bulky for most practical uses. The electronic sound absorber tackles the problem not by trying to catch the sound waves in a trap, but by creating counter-waves that reduce their force or cancel them entirely—somewhat in the fashion of waves on the surface of water being levelled by a similar disturbance travelling in the opposite direction. The device consists of three units—



Arrangement of electronic sound absorber

a special electronic microphone, an amplifier, and a specially-designed small loudspeaker. The microphone, reacting instantaneously to the changes in atmospheric pressure caused by the sound waves, translates these changes into electrical impulses which pass through the amplifier and emerge from the speaker, directly behind the microphone, as counter-waves of equal and opposite pressure. The effect, within a few feet of the speaker, is a substantial levelling of the changes in air pressure and hence a reduction or even elimination of the oncoming sound.

The principle on which the electronic sound absorber works was conceived some time ago, but the application became practical only in recent years with the development of the electronic microphone. Among the particular advantages of the microphone are its uniform sensitivity and response in the low-frequency range with the result that it will perform consistently over a range of more than three octaves. The heart of the microphone is a small vacuum valve called a mechano-electronic transducer, which contains a rod connecting one element of the valve through a vacuum-tight shell directly to the diaphragm of the microphone. The vibration of the diaphragm by the oncoming sound waves is thus transferred directly into a vibration of one of the elements in the valve, developing the current which is passed to the amplifier and the loudspeaker. The design of the loudspeaker was guided by the fact that in this kind of operation, the back of the loudspeaker mechanism has to be enclosed to ensure complete non-interference. To keep this enclosure small in the interest of portability and easy installation, the speaker was designed with a cone diameter of only 3½in. The sound absorber can be built to operate either on battery power or on 110V, single phase, alternating current. The first developmental model, using a ten-valve, transformerless, direct-coupled amplifier, was built for battery power so that it could be tested at sites remote from power lines. A second model, on which work is now progressing, will use an amplifier of only four or five valves, with a suitable transformer coupling the valve to the loudspeaker. Ultimately a transistor amplifier may be developed permitting a far more compact and economical unit.

The design of the absorber means that the microphone and speaker, forming a combined unit, can be installed at some distance from the amplifier and adjacent to the head of an aircraft or automobile passenger or a machine operator. There are numerous possible applications for a low-frequency noise reducer where the position of the person subject to such noise is fixed. In a bed-room, a sound absorber may be installed near the head of a sleeper to cut down traffic noises and other low-frequency sounds. Other possible applications can be found near the source of the noises rather than adjacent to the ear; examples are the installation of one or more sound absorbers next to a noisy motor or at the outlet of an air-conditioning duct already lined with sound-proofing materials to intercept the higher frequency sounds. The absorber also can be used in the same manner as conventional wall materials in a room to handle the low-frequency waves that now escape. Three of them placed at the intersection of two walls with a ceiling, for example, would catch oncoming low-frequency sounds before the waves could reach the surfaces to rebound as echoes. A substantial period of laboratory development lies ahead before the electronic sound absorber reaches the stage of commercial production. But in view of the absence to-day of efficient sound protection in the low-frequency range there may be widespread future applications for this device.

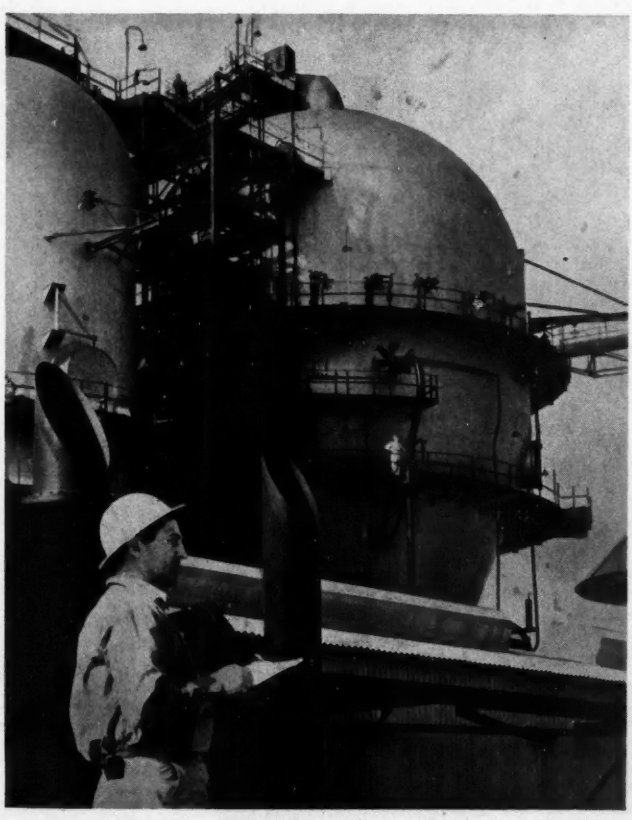
Large Fluid Catalytic Cracking Plant

The Gulf Oil Corporation has now completed its expansion programme at its Girard Point refinery in Philadelphia. The expansion has increased the refinery capacity by 75 per cent, resulting in a new output capacity of 183,000 barrels of refined petroleum products a day. This capacity makes the refinery the largest now operating on the East Coast of the United States.

The plant additions include a catalytic polymerisation unit, an atmospheric and vacuum still and a fluid catalytic cracking plant, which is illustrated in the accompanying engraving. Designed and erected by the M. W. Kellogg Company, of New York, the latter unit is designed for a throughput of at least 63,000 barrels of fresh feed daily, which is said to make it the highest capacity plant of its kind ever built.

The catalytic cracker is a "side-by-side" unit, similar to the one designed and erected by the Kellogg Company for the Gulf Oil Corporation at Port Arthur, Texas, in 1951. The regenerator vessel of the plant is 56ft in diameter by 84ft in height: the reactor vessel is 30ft 8in in diameter by 71ft in height; and the fractionator tower is 20ft in diameter by 125ft in height.

Both the regenerator and the reactor are lined with "Kelcrete" insulating concrete and refractory concrete. In addition to producing high-octane petrol, the new plant will turn out heating oils, fuel gas, propane-propylene and butane-butylene. An additional refining process will convert the propane-propylene into high-octane motor fuel.



Fluid catalytic cracking plant at Girard Point refinery, Philadelphia

Hook-On Volt-Ammeter

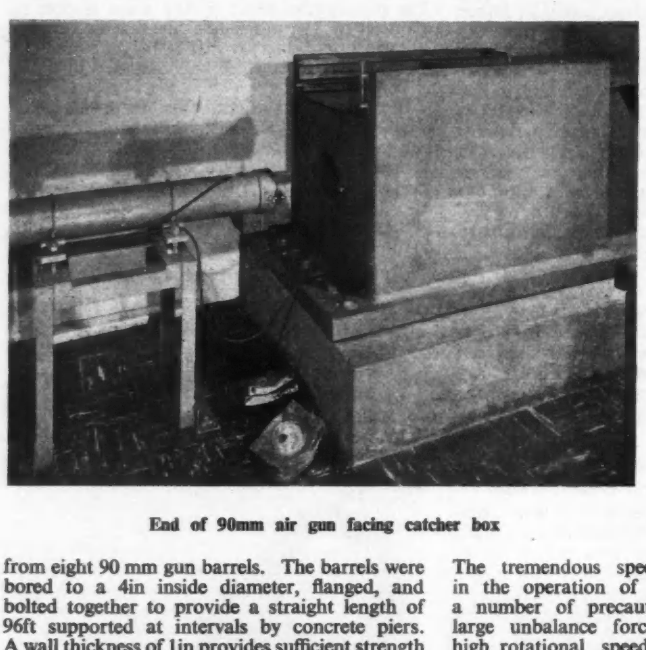
The General Electric Company, of Schenectady, New York, is now manufacturing a hook-on volt-ammeter which is believed to be the first such instrument with a positive scale-changing device. The instrument, which is shown in the accompanying illustration, is a pocket-size unit designed to measure both current and voltage quickly and accurately. Its positive scale-changing mechanism eliminates the possibility of reading the wrong scale for any particular application. The desired range and scale is obtained by turning the switch knob situated at the base of the unit. It has a current range of 5/20/80/350A, thus covering the extent of currents normally encountered in industrial and commercial circuits. The instrument is also capable of measuring alternating voltage in three ranges of 150/300/750V without auxiliary equipment, providing accuracy up to 3 per cent of full scale, and withstanding a voltage breakdown test of 4kV a.c. The instrument will clamp around any conductor up to 2in in diameter. Its contoured trigger closes and opens the hook-on assembly, which is covered with insulation as a safeguard against grounding or short-circuiting. The current scales are marked in black and the voltage scales in red. The instrument weighs 1¼ lb and measures 9½in by 3 7/16in by 1 9/16in.

Hook-on volt-ammeter with scale changing knob

Acceleration Testing Rigs

SEVERAL interesting shock and acceleration simulation devices have recently been completed and are providing improved facilities for the ordnance development activities of the National Bureau of Standards. The new equipment is used primarily to study the effects of high accelerations on experimental ordnance components. The major equipment housed in the Air Gun Building of the N.B.S. includes two air guns, one of them 96ft long ; a wind tunnel, having a velocity of 300ft per second ; and four centrifuges, one of which can produce accelerations of 60,000 *g*. on specimens weighing 1 lb. There is also a new 91ft drop tower, which is used for studying the effects of various shock impacts on experimental objects.

The larger of the two air guns was constructed from eight 90 mm gun barrels. The barrels were bored to a 4in inside diameter, flanged, and bolted together to provide a straight length of 96ft supported at intervals by concrete piers. A wall thickness of 1in provides sufficient strength to allow considerable latitude in working pressures. In the N.B.S. air gun the acceleration forces are not caused by the sudden application of a very high air pressure to the projectile to give it a high initial acceleration. Instead, low-pressure air gradually brings the projectile (inside which are mounted the components to be tested) up to speed along the length of the tube ; then, to produce the desired accelerating force, the fast-moving projectile is rapidly stopped by letting it plough into a catcher box filled with sand, lead or other material, as shown in the accompanying illustration. By using projectiles of different materials and shapes, by adjusting the propelling force so as to produce different muzzle velocities, and by filling the catcher box with different materials, a wide range of negative accelerations can be applied to the components under study. A tank of 70 cubic feet capacity, which is fitted with a quick-release valve, supplies the propelling air at a pressure of 125 lb per square inch. The impact velocities of the projectiles are determined either photo-electrically or by measuring the time interval between the breaking of two wires. The projectiles used weigh from 6 lb to 18 lb and attain velocities as high as 880ft per second. The weights and speeds are thus comparable to those of an actual ordnance projectile fired from a weapon such as a trench mortar. The steel test projectile smashes into a stack of lead plates in the catcher box with such force that it often penetrates some 8in into the lead.



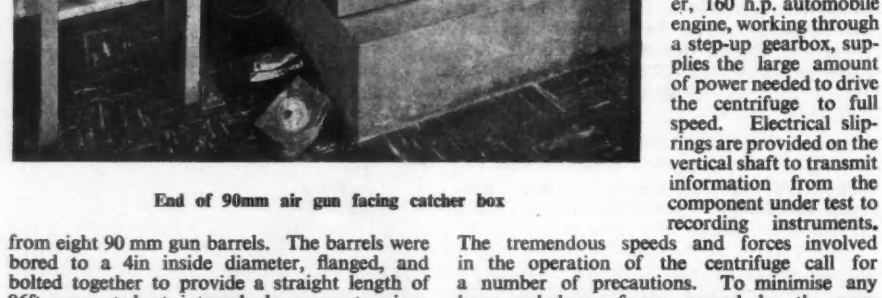
End of 90mm air gun facing catcher box

The N.B.S. Ultra-High-*g* Centrifuge was developed co-operatively by the Raymond Engineering Laboratory and the Bureau to apply an acceleration of 60,000 *g* to two specimens weighing as much as 1 lb each. The specimens rotate in a 37in diameter circle with a full speed of 11,000 r.p.m.; at this speed the specimens have a velocity of about 1200 m.p.h. and the force at the hub section is more than 830,000 lb. The arm, which is shown in the accompanying illustration, was machined from S.A.E. 4340 steel heat treated to an ultimate tensile strength of 176,000 lb per square inch. The 2in thick steel chamber in which the arm rotates is designed to be evacuated or filled with helium, if desired. An eight-cylinder, 160 h.p. automobile engine, working through a step-up gearbox, supplies the large amount of power needed to drive the centrifuge to full speed. Electrical slip-rings are provided on the vertical shaft to transmit information from the component under test to recording instruments. The tremendous speeds and forces involved in the operation of the centrifuge call for a number of precautions. To minimise any large unbalance forces caused by the very high rotational speeds, the arm shaft bearing assembly is mounted on rubber O-rings. This allows the assembly to seek its own rotational centre when acted on by an unbalanced load. Means had to be provided for measuring any dynamic unbalance that may occur over the entire speed range. This was accomplished by means of two strain gauges mounted on a beam over the drive shaft ; the output from the gauges is fed to control oscilloscopes which indicate any serious unbalance. A reinforced concrete archway, 3ft wide by 6in thick, provides protection in the plane of rotation of the centrifuge arms.

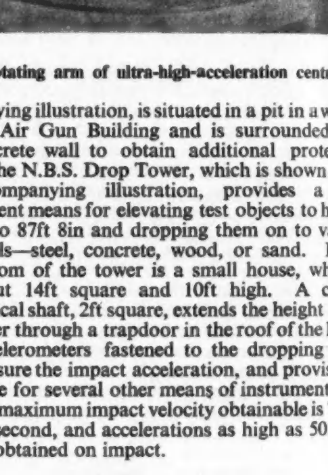
The N.B.S. Heavy-Duty Low-*g* Centrifuge was constructed to permit the testing of relatively heavy components weighing up to 150 lb under the influence of relatively low acceleration forces ranging up to 100 *g*. The ends of the arms of this big centrifuge describe a circle 29ft in diameter ; this large diameter was selected to minimise the variation in *g* throughout the specimens under test. The power to drive the unit at speeds up to 165 r.p.m. is provided by a 20 h.p. motor-generator set. The centrifuge, which is shown in the accompanying illustration, is situated in a pit in a wing of the Air Gun Building and is surrounded by a concrete wall to obtain additional protection.

Rotating arm of ultra-high-acceleration centrifuge

The N.B.S. Drop Tower, which is shown in the accompanying illustration, provides a convenient means for elevating test objects to heights up to 87ft 8in and dropping them on to various anvils—steel, concrete, wood, or sand. In the bottom of the tower is a small house, which is about 14ft square and 10ft high. A central vertical shaft, 2ft square, extends the height of the tower through a trapdoor in the roof of the house. Accelerometers fastened to the dropping block measure the impact acceleration, and provision is made for several other means of instrumentation. The maximum impact velocity obtainable is 74·5ft per second, and accelerations as high as 50,000 *g* are obtained on impact.



Rotating arm of heavy duty, low acceleration centrifuge



91ft drop tower

Industrial and Labour Notes

Coal Production

The annual conference of the National Union of Mineworkers was held at Blackpool last week, and on Wednesday the delegates were addressed by Sir Hubert Houldsworth, chairman of the National Coal Board. Sir Hubert spoke about the reorganisation of the coal mining industry which had been going on since nationalisation, and dealt in some detail with the Coal Board's development programme. He said that a good deal of the additional capital which had been invested in the industry since vesting day had done no more than replace wasting assets and was necessary merely to maintain productive capacity. Moreover, about £75,000,000 had been spent on schemes which were not yet completed. Consequently, Sir Hubert remarked, all the capital investment did not result in obtaining an immediate increase in output ; there was a deferred action.

Notwithstanding that, Sir Hubert continued, in the period since vesting day output a manshift had increased from 1·07 tons to 1·22 tons, which was the highest in the history of the industry, and it should be remembered that those figures referred to saleable coal and not to material raised and weighed. Each year the extraneous matter removed from the coal raised and weighed increased by about ½ per cent, or roughly 1,000,000 tons, and had to be made good before saleable output was maintained. Thus, since vesting day, the quantity of extraneous matter removed yearly had increased by about 8,000,000 tons. But, Sir Hubert said, if the accretions of output from capital works had to be awaited before there was a pronounced increase in output, one or two anxious winters would have to be met, and he wondered if that was necessary. He was satisfied, he continued, that the difficulties could be met by an improvement in labour relations, resulting in increased co-operation between men and management at the pits ; by taking up the "remaining slack" and by prompt attention to hindrances to production at individual pits. That, Sir Hubert remarked, was why the union and the board were jointly of opinion last January that a 2½ per cent increase nationally in coal production in 1954, with existing underground manpower, was a reasonable minimum aim. Since then, there had been no reduction in underground manpower. Up to date the output of deep-mined coal was up by 1,500,000 tons compared with the corresponding period of 1953, but the bulk of that increase was attributable to the extra working day owing to the absence this year of the additional Coronation holiday. To achieve the objective, it was necessary to get approximately 3,750,000 tons extra in the remaining half of this year. Neither the Coal Board nor the union, Sir Hubert added, sought to deny that the industry was capable of doing better with the pits as they were and with men and management as they were.

Sir Hubert went on to say that better discipline was needed in the pits. That was a two-way traffic in which management and men must play their parts. He thought that the relationship between the divisional boards and the union's area committees generally continued to improve, although there were some areas where there ought to be speedier improvement. But, Sir Hubert commented, it was possible to have good relations at the top level and yet, at the same time, to have unsatisfactory relations at the pit level. If proper discipline could be ensured at the pits, there would not be the melancholy loss of over 700,000 tons of coal this half year from unofficial stoppages, a figure which was an increase of about 50 per cent on the loss sustained in the corresponding period of 1953. Nor was that figure the real measure of the loss, for the unrest before and after a stoppage frequently caused losses which were not easy to apportion statistically. Both the union and the board deplored the need to import coal, yet, while the amount of coal imported last year was 557,000 tons, the amount lost by stoppages of work through disputes was 939,000 tons, and this year, so far, the proportion was about the same. It was a state of affairs, Sir Hubert said, which must be avoided. The established conciliation machinery could deal with disputes, and did so, in fact, in most coalfields. He thought the time had come when local rules or customs at pits, which were not in keeping with modern circumstances, should be revised.

Sir Hubert concluded his address by saying that in conditions of full employment reliance could not be placed upon increasing the labour supply, but must rather be placed upon increasing efficiency through mechanisation, greater co-operation and training. The re-emergence of world competition and the struggle for markets emphasised the necessity for increasing efficiency and increasing productivity. Furthermore, it should be remembered that there were potential competitors in oil and atomic energy, both at home and abroad, and possibly from natural gas also. But the most skilfully laid-out pits, and the invention, fabrication and use of ever more efficient machinery could not alone secure maximum efficiency in the coal mining industry. It must be accompanied by real co-operation between management and all at the pits, and that co-operation was something which the Board and the union must both seek to improve.

National Coal Board's Statistics

This week the National Coal Board has issued a statistical statement of the costs of production, proceeds and profit or loss of collieries for the first quarter of this year. The Board has estimated that there was a surplus of £754,461 after meeting all charges, including £4,650 000 estimated as the interest payable to the Minister of Fuel and Power.

The total saleable tonnage of coal from the Board's mines during the first quarter was 55,137,291 tons, the amount disposed of commercially being 51,128,798 tons. The proceeds amounted to £172,767,158 and the total costs of production to £164,739,697, so that the profit on the sale of coal, before allowing for interest, was £8,027,461. The estimated profit on opencast working during the quarter was £750,000 and the profit of the Coal Board's ancillary undertakings has been put at £367,000.

The statement shows that of the mining costs, totalling £164,739,697, wages, including holiday pay and allowances in kind, accounted for £103,877,456, and that roofs supports, general stores and repairs took up £26,857,849. The average weekly cash earnings during the quarter were £13 19s. 3d. for face workers, and £9 15s. 5d. for surface workers.

Overseas Trade

The provisional figures about the United Kingdom's overseas trade in June, which have been issued by the Board of Trade, put the value of exports of United Kingdom goods at £217,700,000. June was a short working month with only twenty-four working days and the Board of Trade says that the improvement recorded in the first quarter of this year, compared with 1953, was substantially maintained during the second quarter. In the first half of this year, the value of exports of United Kingdom goods averaged £224,100,000 a month, which was 7 per cent more than in the corresponding period last year, although it was only 1 per cent above the monthly average for the second half of 1953. Re-exports in June were valued at £8,800,000, and for the first half of this year were virtually the same as in the first half of 1953. The figures show also that imports in June were valued at £291,000,000, which included aircraft valued at £7,000,000 received as a gift from Canada. The monthly average rate of imports for the first half of the year was £279,200,000, a reduction of 1 per cent compared with the same period last year. The excess of imports over total exports in June was £64,500,000, the average rate of excess for the first six months being £46,100,000, or 28 per cent lower than the rate for the first half of 1953.

Employment and Unemployment

The Ministry of Labour's report on the employment situation in Great Britain in May states that the working population increased by 37,000 to a total of 23,515,000 (15,926,000 men and 7,589,000 women). At the end of the month there were 22,427,000 (14,946,000 men and 7,481,000 women) in civil employment, which was the highest number ever recorded in this country in peacetime.

An analysis of civil employment in May shows that 4,014,000 people were at work in the basic industries, which was 16,000 more than a month earlier. The whole of this increase was a seasonal one in agriculture and transport, the number of people at work in mines and quarries falling slightly. In the manufacturing industries, the net addition to the labour force in May was 29,000, making a total at the end of the month of 8,999,000. In this industrial group there was an addition of 10,000 to the number employed in the engineering, metal goods and precision instrument industries, bringing the total to 2,628,000, and in vehicle manufacturing an increase of 3000 brought the total number employed to 1,173,000. In other industries and services, the number of people employed in building and contracting increased by 10,000 to 1,426,000, and in the classification "professional, financial and miscellaneous" there was an addition of 20,000, bringing the total engaged in that group to 3,983,000.

The unemployment figures given in the statement show that on June 14th the number of people registered as out of work was 239,521, which represented about 1·1 per cent of the total number of employees, and was nearly 50,000 less than the number of unemployed registered on May 10th. The June figure included 12,873 who were described as temporarily stopped. The Ministry of Labour says also that in the week ended May 29th about 41,400 operatives in manufacturing establishments rendering returns were reported to be on short time, losing ten and a half hours each on the average, and that 1,498,000 production workers were working on an average eight hours' overtime.

Dangerous Machines Order, 1954

The Minister of Labour has made the Dangerous Machines (Training of Young Persons) Order, 1954, which is to take effect on August 1st. This Order prescribes machines at which young persons must not work unless they have been fully instructed as to the dangers arising and the precautions to be taken, and have either received a sufficient training or are under adequate supervision. The Order, which has been made under Section 21 of the Factories Act, 1937, makes some additions to the list of machines prescribed in a similar Order made in 1938. The additions include certain textile, laundry and confectionery machines, worm pressure extruding machines, loose knife punching machines, wire stitching machines, corner staying machines and semi-automatic wood turning lathes.

It will be recalled that the recently published report of the Chief Inspector of Factories stresses the continuing need for ensuring that young persons under eighteen who are working in factories are given adequate and proper instruction in the dangers of machines and the precautions to be observed. This instruction should include the proper use of guards and safety devices required to be provided under the Factories Acts. The extension of the list of "prescribed machines" is based on statistics kept by the Chief Inspector of Factories, which indicate that the machines included cause a high percentage of the accidents to young people.

Notes and Memoranda

Air and Water

COASTAL SHIPPING ADVISORY COMMITTEE.—The British Transport Commission announces that it has nominated Messrs. Blee, C. K. Bird and J. R. Pike to the Coastal Shipping Advisory Committee to replace Messrs. T. F. Cameron, C. P. Hopkins and D. Murray.

COMMODORE ENGINEER.—We are informed by the Peninsular and Oriental Steam Navigation Company that the Commodore Engineer of the Fleet, Mr. W. D. Stiven, has retired and that he has been succeeded by Mr. W. D. Pacey, the chief engineer of the "Strathmore."

LLOYD'S WRECK RETURNS.—Lloyd's Register of Shipping has issued its return of merchant ships totally lost or broken up, for the quarter ended December 31, 1953. Steamships and motorships totally lost consequent upon casualty totalled fifty-four ships of 57,341 tons gross which world total includes eight ships of 7261 tons gross belonging to Great Britain and Northern Ireland and six ships of 943 tons gross owned by the Commonwealth countries. The corresponding returns for ships lost not consequent upon casualty are eighty-nine ships of 293,456 tons gross, twenty-two ships of 75,003 tons gross and five ships of 7098 tons gross, respectively.

ROYAL NAVAL ENGINEERING COLLEGE.—It is announced by the Admiralty that a large accommodation block is to be built at the Royal Naval Engineering College, Manadon, known as H.M.S. "Thunderer." The block, when complete, will permit the centralisation of training of officers of the Engineering Branch of the Navy at Manadon, so that the buildings at Keyham, erected in 1880, will cease to be used as part of the College accommodation. Manadon House and adjoining land was purchased by the Admiralty in 1936 for future development as a college and some description of the progress made appeared in the issues of THE ENGINEER dated February 24 and March 3, 1950.

AIRPORT ACTIVITY.—Air transport movements at United Kingdom aerodromes in May numbered 19,350, which was 5 per cent more than in May, 1953. The total of passengers handled was 342,000, or 12 per cent more than a year earlier. Freight on and off-loaded amounted to 7700 short tons, an increase of 30 per cent on the corresponding month of last year. Post Office mail set down and picked up during the month increased slightly from last year's figures to 1250 short tons. The Ministry of Transport says that London and Northolt airports together handled 192,000 passengers, or 8 per cent more than in May, 1953. At London airport there were 5330 air transport movements (an increase of 25 per cent over May, 1953) and 147,200 passengers were handled (34 per cent more than in May, 1953). Northolt air transport movements decreased by 33 per cent to 2310, and passengers by 34 per cent to 44,700. Other airports at which passenger traffic increased considerably over May, 1953, were Manchester, Glasgow, Belfast, Birmingham, Blackbushe and Edinburgh.

Miscellanea

CHEMICAL RESEARCH AT TEDDINGTON LABORATORY.—An exhibition of the work in progress is to be held at the Chemical Research Laboratory, Teddington, during a series of open days, from Tuesday, September 28, to Thursday, September 30, next. Applications from industrial firms not in the laboratory's mailing list for invitations, should be sent to the Director not later than August 31st.

GRAIN BLOWER.—Scottish Mechanical Light Industries, Ltd., 42–44, Waggon Road, Ayr, is now producing an "Electromatic" grain blower which is powered by a 3 h.p. electric motor, and is capable of blowing 4 tons of grain per hour up into a 20ft silo. The same unit can convey 2 tons 15 cwt per hour 20ft vertically, plus 53ft horizontally, with the piping including two 90 deg. bends and a 90 deg. outlet.

IJORA POWER STATION.—As part of the development programme of the Electricity Corporation of Nigeria, Mirrless, Bickerton and Day, Ltd., has supplied two mark K.V.S.12 pressure-charged diesel engines to the Ijora "A" power station. The engines have twelve cylinders, in vee form, of 15in bore by 18in stroke, and each has a continuous site rating of 1800 b.h.p. at 375 r.p.m., and an overload of 2020 b.h.p. They are direct-coupled to Brush alternators having a continuous rated output of 1250kW and 1400kW overload.

FLEXIBLE RUBBER BLOCK COUPLINGS.—We are informed by the Holset Engineering Company, Ltd., that it has recently completed a 180 h.p./r.p.m. flexible rubber block coupling which is intended to transmit 6300 h.p. at 35 r.p.m. in the main drive of a large sheet steel roughing mill in France. The company has also completed a size 80 h.p./r.p.m. coupling for the main drive of an aluminium roughing mill, to transmit a peak load of 3850 h.p. at 51 r.p.m. with twelve reversals in four minutes. This design of coupling was described in the July 22, 1949, issue of THE ENGINEER.

GERMAN LIGHT ALLOY INDUSTRY.—The German Fachvereinigung Leichtmetall-Waren (Light Alloy Goods Manufacturers' Association) held its annual general meeting on June 18th at Kronberg (Taunus). It was stated that the turnover of the industry in 1953 amounted to 290 million D.M., compared with 120 million in 1936, 195 million in 1951, and 217 million in 1952. Consumption had increased particularly in building, interior furnishing, container industry, and export. Complaints were voiced against the policy of export subsidies in foreign countries, particularly in Austria.

MACHINE TOOL SHOWROOMS.—M. C. Layton, Ltd., 96–98 Victoria Street, London, S.W.1, has opened new showrooms at Abbey Wharf, Mount Pleasant, Alperton. The company has on view a large number of new machine tools and power presses, as well as a selection of second-hand machinery and equipment. Any machine tool can be quickly shown in operation, and it is proposed to have each make in turn demonstrated by maker's staff for one week each month. The information service regarding available machine tools, which has been in operation since 1937, will be continued.

WORK SIMPLIFICATION.—A course on work simplification is to be held at the Roffey Park Institute, Horsham, Sussex, from Monday, September 27th to Friday, October 1st, next. The aim of this course is to provide a comprehensive treatment of the practice and principles of work simplification. In these courses, emphasis is placed on the development of an analytical and objective approach to the subject rather than on the acquisition of proficiency in mechanics of the various techniques. Particular attention is given to the social and economic implications, and the subject is dealt with by lecture-discussions, demonstrations and exercises undertaken by the delegates themselves.

MAGNESIUM INDUSTRY COUNCIL.—The Magnesium Advisory Committee which was formed early in 1952 has now been reconstituted as the Magnesium Industry Council. It is stated that the Council will continue the activities of the committee as a consultative and advisory body, and has extended its scope through the formation of panels of technical and commercial experts. The purpose of the Council is to promote the production and use of magnesium and its alloys; its services being available to industry and to the Ministries responsible for the defence programme. The chairman of the Council is Mr. E. Player, of Birmid Industries, Ltd., and the secretaries are Wenham Brothers and Co., 21, Bennett's Hill, Birmingham.

AUTOMATIC DUST CONTROL UNIT.—An automatic shaker mechanism for the filter media of its fabric dust collectors has been designed by Dallow Lambert and Co., Ltd., Spalding Street, Leicester. It consists essentially of special control gear which governs the electrically driven shaking mechanism. This control gear is interlocked with the fan motor starter so that the shaking time cycle is commenced when the fan has come to rest after the motor is switched off. As it is essential that the filter should not be shaken whilst air is passing through the fabric, the control gear is so arranged that during both the first time interval and the shaking period, and also for a short time after shaking, it is not possible to restart the fan. After the time cycle has been completed the mechanism resets itself ready for the next operation.

SALTERS' INSTITUTE OF INDUSTRIAL CHEMISTRY.—On the recommendation of the director, Sir Alfred Egerton, the Court of the Salters' Company has elected Mr. G. Hetherington to be a Salters' Fellow for the year 1954–55, and has extended the Fellowship held by Mr. P. P. Manning for a second year. Mr. Manning held a Salters' Fellowship during 1953–54, while carrying out research work in the Chemistry department, Leeds University, on "Chemical Kinetics of Cyclic Monomers Forming Linear Polymers," and theoretical studies on the "Polymerisation of Olefines." Mr. Hetherington who held a Salters' Scholarship during 1953–54, has been working in the chemistry department at King's College, Newcastle upon Tyne on "The Chemistry of Nitryl Fluoride." The Court has also elected five Salters' Scholars for the year 1954–55.

PHASE TRANSFORMATIONS IN METALS.—The Metal Physics Committee of the Institute of Metals proposes to hold in London a one-day symposium on "The Mechanism of Phase Transformations in Metals." The date of the proposed symposium will probably be in November, 1955. The symposium will be in two parts, one devoted to transformations which are largely governed by thermal activation (nucleation and growth reactions) and the other to transformations in which thermal activation is less important (martensitic reactions). Review papers are being invited to introduce each session, but in addition the Committee will be glad to consider offers of short original contributions from workers in the field of phase transformations. In these contributions emphasis should be laid on the experimental results and their interpretation rather than on details of experiment technique.

CORROSION OF STRUCTURAL STEELWORK.—A critical abstract of the first five sets of "Specifications for Cleaning and Painting Steel Structures," issued by the Steel Structures Painting Council of Pittsburg, U.S.A., is available free of charge from the British Iron and Steel Research Association, (Corrosion Section), 140, Battersea Park Road, London, S.W.11. The abstract was originally prepared by Dr. J. C. Hudson, head of the B.I.S.R.A. Corrosion Section, for the Corrosion and Electrodeposition Committee of the Inter-Service Metallurgical Research Council. The five sets comprise twenty-eight individual specifications, dealing respectively with surface preparation, pretreatment, paint, paint systems, and paint application. The Steel Structures Painting Council of America has come into existence within the last few years. It comprises representatives of about twenty prominent American organisations, including the service departments, railroads research establishments and trade associations. B.I.S.R.A. says that in many respects the Council is not very different from the British Corrosion Committee. But it differs from the Committee in the fact that the engineering institutions are officially represented, in its restriction to the structural field, and in the emphasis given to the preparation of a code of practice.

CONFERENCE ON INDUSTRY AND SCIENCE.—Last Friday, the Manchester Joint Research Council held a one-day conference to discuss a report on "Industry and Science," which it issued in March last. This report, which was reviewed in a leading article in our issue of April 2nd, contained the findings of a survey made by the Council to assess the relationships between industry and science in the greater Manchester area. The report was based on evidence provided by 225 firms. Speakers at last week's conference included Mr. Geoffrey Parker, chairman of the Manchester Joint Research Council, Sir Charles Renold, a vice-chairman of the Council; Dr. F. C. Toy, director of the British Cotton Industry Research Association, and Professor Ely Devons, of Manchester University.

COAL PRODUCTION.—Last week's deep-mined coal output amounted to 3,801,800 tons and opencast to 219,100 tons, making a total of 4,020,900 tons. Holidays have now started in the various coalfields, the deep-mined tonnage lost last week as a result of recognised holidays being estimated at 642,500 tons. In the first twenty-seven weeks of this year, ended last Saturday, coal output was 120,116,600 tons, compared with 118,951,500 tons in the corresponding period of last year. Coal imports in the first twenty-seven weeks of this year amounted to 450,800 tons. In the week ended July 3rd, there were 707,500 wage-earners on colliery books, 290,600 of whom were working at the coal face. In the same week, inland coal consumption, exports and bunkers took up 4,030,000 tons, and distributed stocks totalled 14,685,000 tons, which was a slightly lower figure than that given for the comparable week of last year.

Personal and Business

MR. R. J. SHELL has been appointed proving engineer of C.A.V., Ltd., Acton, W.3.

APEX (TRINIDAD) OILFIELDS, Ltd., states that its postal address is now Fyzabad, Trinidad, B.W.I.

MR. M. J. CRAWFORD, A.M.I.C.E., has been appointed managing director of the Wayne Tank and Pump Company, Ltd.

MR. J. S. ARMSTRONG has been appointed marine representative in the technical department of Jenolite, Ltd., 13–15, Rathbone Street, London, W.1.

G. J. WORSSAM AND SON, Ltd., Wenlock Road, London, N.1, which is in the Vickers group of companies, is now entitled Vickers-Armstrongs, Ltd., Worssam Products.

MR. J. WRIGHT, director and general manager of the Dunlop Rim and Wheel Company, Ltd., Coventry, has been appointed a director of Dunlop Rubber Company, Ltd.

MR. W. MCCONNACHIE has retired from the a.c. motor design section of the British Thomson-Houston Company, Ltd., Rugby, after forty-three years in the company's service.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces the appointment of Mr. W. G. Dumville as north-eastern regional manager, in succession to Mr. E. Charlton, who is retiring.

GRIFFIN AND TATLOCK, Ltd., and W. AND J. GEORGE AND BECKER, Ltd., have amalgamated under the title of Griffin and George, Ltd. Mr. R. McKinnon Wood is the chairman of the new company.

SMALL AND PARKES, Ltd., Manchester, states that, after July 20th, the address of its Belfast depot will be 67, Dublin Road, Belfast (telephone, Belfast 28967). Captain J. Douglas is the area manager.

MR. A. W. PAGE has been appointed London manager of Igranic Electric Company, Ltd., in succession to Mr. N. V. Baldwin, who has become managing director of Brookhirst-Igranic S.A. (Pty.), Ltd.

MR. R. H. BINGHAM has retired from the board of Huntington, Heberlein and Co., Ltd., after forty-four years in the company's service. Mr. S. Robson and Mr. R. B. Sharp have been appointed directors.

MR. MARK RADIVAN has been appointed chairman and managing director of De Bergue Machine Tools, Ltd., Strangeways Ironworks, Manchester, 3. Mr. R. H. Moon has been appointed a director of the company.

MR. E. A. O'NEAL, Jun., chairman of Monsanto Chemicals, Ltd., has resigned from the board of Monsanto Chemicals (Australia), Ltd. Mr. P. A. Singleton, managing director of the British company, has been elected in his place.

MR. HARRY FERGUSON has resigned from the chairmanship and from the board of Massey-Harris-Ferguson, Ltd., in order to develop a number of new inventions outside the agricultural machinery field. Mr. James S. Duncan has succeeded to the chairmanship of Massey-Harris-Ferguson, Ltd.

MISS G. BINGHAM has retired from the assistant secretaryship of the Newcomen Society, and from July 28th all communications for the Society should be addressed to the Science Museum, South Kensington, S.W.7 (telephone, Kensington 1793). Mrs. Bartholomew has been appointed assistant secretary.

THE BRITISH ELECTRICITY AUTHORITY states that Mr. F. H. S. Brown, M.I.Mech.E., M.I.E.E., has been appointed generation design engineer at headquarters, in succession to Mr. F. Shakeshaft, who is to concentrate on future design and special generation problems. Mr. W. B. Shannon, M.I.C.E., M.I.Mech.E., M.I.E.E., has been appointed chief generation engineer (construction) of the London division of the Authority.

British Patent Specifications

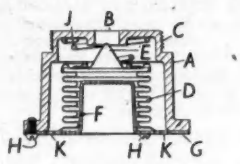
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

STEAM TRAPS

711,051. April 12, 1951.—IMPROVEMENTS IN STEAM TRAPS, W. M. Still and Sons, Ltd., 29–31, Greville Street, Hatton Garden, London, E.C.1. (*Inventor: Frederick William Still.*)

The drawing shows in section a steam trap according to the invention for use in an upright position. *A* is the bell-like casing, the upper end of which is formed with an axial inlet *B* and threaded at *C* for attachment to the element to be relieved of water. The expansible fluid-containing, bellows-like chamber consists of a corrugated thimble *D* whose closed end is formed with a hollow valve piece *E* and an



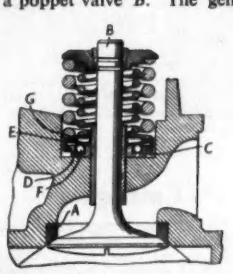
No. 711,051

inner thimble *F* having an extended flange *G* that forms the casing cover plate attached by screws *H* to the casing. The lower end of the thimble *D* is soldered to the cover plate flange; the space between the thimbles is charged with expansible fluid. *J* is a spring interposed between the thimble *D* and the closed end of the casing to steady the axial expansion of the thimble and promote its collapse as it cools. *K* are open discharge passages or slots in the cover plate flange. It is found that a trap according to the invention is very sensitive, while the bellows is so responsive to changes of temperature that no adjustment is needed with fairly wide variations in steam pressure.—*June* 23, 1954.

INTERNAL COMBUSTION ENGINES

710,512. October 10, 1951.—VALVE-ROTATING DEVICE, Thompson Products, Inc., 2196, Clarkwood Road, Cleveland, Ohio, U.S.A. (*Inventor: John A. Newton.*)

This invention relates to a self-contained device for rotating poppet valves. The drawing shows a portion of the cylinder head of a radial aircraft engine with combustion chamber and exhaust port. As an example of the two parts between which relative rotation is desired, one part could be a seat ring *A* and a poppet valve *B*. The general design

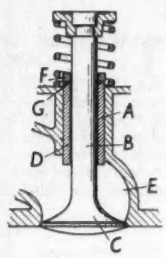


No. 710,512

of the valve is shown in the drawing. The valve rotating device *C* is composed of a retainer *D*, which is prevented from rotation by the downward pressure exerted by the valve springs, a valve spring seating collar *E* acted on by the springs and balls *F*, carried in dished grooves in the retainer. A spring washer *G* between the retainer and the spring seating collar is arranged to deflect under increased spring loads, such as when the valve is moved to open position, to transfer the spring load from the retainer *D* to the balls therein. The transferred load causes the balls to roll down the dished grooves toward the centres, and thereby rotates the washer *G* which, in turn, rotates the collar *E*, the springs and the valve *B*.—*June* 16, 1954.

711,108. July 18, 1952.—PACKING DEVICE FOR A VALVE, Daimler-Benz Aktiengesellschaft, of Stuttgart-Untertürkheim, Germany.

The invention relates to a packing device for a poppet valve and primarily aims at preventing the penetration of lubricating oil into the valve guide. Referring to the drawing, in the valve guide *A*, inserted in the cylinder head of the engine, the valve stem *B* of the valve *C* is guided with a certain clearance *D* of the ordinary size which is exaggerated in the drawing. The valve is an induction valve for controlling the inlet port in a valve chamber *E*. In accordance with the invention, a plate or ring *F* is passed from above on to the valve stem and is seated on the top end of the valve guide *A*. The axial thickness of the ring *F* is less than the diameter of the stem *B*. This ring embraces the valve stem with a clearance which is smaller than the clearance *D*, and bears, by reason of its weight, on the end surface *G* of the valve guide. The small clearance between the ring *F* and the valve stem has the effect that only such small amounts of oil can pass from above through the gap between the ring and the stem on to the running surface of the valve stem as are absolutely necessary for the adequate lubrication of the valve stem; otherwise the admission of oil into the valve guide is prevented.—*June* 23, 1954.



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BEARINGS AND SUPPORTS

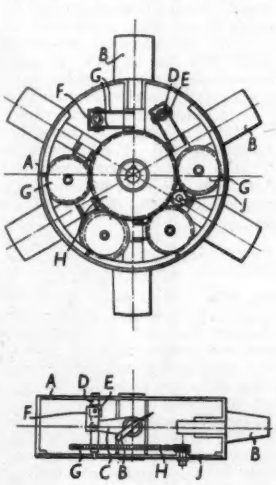
710,913. March 13, 1952.—LUBRICANT FOR HEAVY JOURNAL BEARINGS OPERATING AT HIGH TEMPERATURES, Standard Oil Development Company, Elizabeth, New Jersey, U.S.A.

By the invention the break-away starting torque and also the friction resistance at very low speeds in standard paper machinery and similar equipment may be very materially reduced by adding to the conventional mineral lubricating oil small quantities of an "oiliness" agent. For general purposes a mineral base lubricating oil having a viscosity between about 50 and 200 S.S.U. at 210 deg. Fah. is preferred though non-mineral oils can be used. The oil has added to it from about 0·05 to 1 per cent, preferably 0·1 to about 0·5 per cent of the substantially saturated fatty acids having preferably 16 and not more than about 26 carbon atoms, plus 0·01 to 2 per cent, preferably 0·05 per cent to 0·5 per cent by weight, of the long chain alkenylated dibasic acid or mercapto-acetic acid. To these is added 0·1 to 5 per cent by weight, preferably not more than about 3 per cent, of the load-bearing composition, such as tricresyl phosphate or the active chlorine type materials and others which are well known, such as active sulphur type compounds. Examples of the uses of such lubricants are given in the specification.—*June* 23, 1954.

TURBINES AND BLOWERS

710,579. January 31, 1952.—AXIAL-FLOW BLOWERS AND TURBINES, Demag Aktiengesellschaft, Werthauser Strasse 64 (22a), Duisburg, Germany.

By the invention means are provided for adjusting the blades of impellers or rotors of axial-flow blowers, turbines, &c. As shown in the drawing, on the periphery of the hub *A* of an axial-flow impeller are rotatably mounted blades *B*, to the shanks of which are secured pairs of parallel levers *C*, which



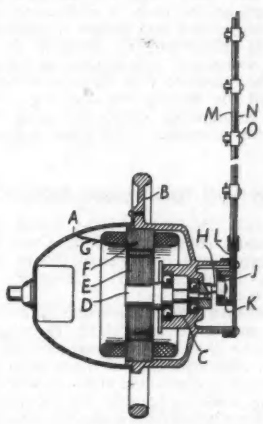
No. 710,579

straddle the threaded spindles *D* in the manner of a fork. The spindles carry nuts *E*, connected to the ends of the levers by U-shaped links *F*. Toothed wheels *G*, which engage in a toothed wheel *H*, are secured on the spindles *D* to rotate the spindles. With the toothed wheel *H* engages a pinion *J*, which is driven directly, or through further gearing, by hand or by a motor, and actuates the wheels *G* of the spindles *D* through the wheel *H*, so that the nuts *E* are displaced axially, the blades being thus rotatably adjusted by the links *F* and the arms *C*. It is advantageous for the spindles *D* to have a thread of fine pitch, as it is then possible to obtain a very great reduction in speed, which then renders it possible for the parts transmitting the force to the spindles to be of a light compact construction. Due to the high reduction of speed, any play in the toothed wheel gearing does not have any effect on the adjustment of the blades. The means according to the invention may also be used in impellers of multi-stage blowers.—*June* 16, 1954.

AGRICULTURAL ENGINEERING

710,551. August 21, 1952.—ELECTRIC HEDGE CUTTERS, Jens Christian Kristensen, Ostergarde 45, Herning, Denmark.

According to the invention, an ordinary squirrel-cage motor is provided to drive the set of reciprocating knives, the rotor diameter of the motor



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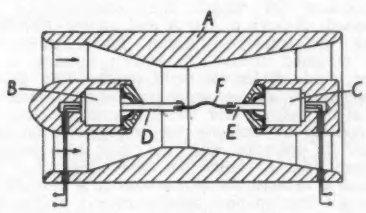
being substantially larger and the rotor length considerably smaller than the corresponding dimensions for a motor of the same output and normal rotor dimensions. As the drawing shows, the hedge cutter comprises a casing *A* provided with a handle *B*, by which the cutter may be held during operation. The handle is shaped like an automobile steering wheel. At one end the casing is provided with a bearing *C* for the shaft *D* of the rotor *E* of a short-circuit motor, which also includes a stator *F* and windings *G*. A crank pin *H* with a roller *J* mounted on it is connected to the outer end of the shaft, the roller being disposed within a recess *K* on a bar *L* carrying knives *M*. Rotation of the crank pin with its roller causes the knives to reciprocate in relation to fixed knives carried by a bar *N* fixed to the casing *A*, the knives being guided in relation to each other by bushings *O*.—*June* 16, 1954.

AERONAUTICAL ENGINEERING

710,970. November 19, 1951.—APPARATUS FOR DETECTING ICING CONDITIONS, Joseph Lucas (Industries), Ltd., formerly known as Joseph Lucas, Ltd., Great King Street, Birmingham, 19. (*Inventors: Edward Atkins and Donald Alwyn Underwood.*)

When an aircraft is fitted with de-icing equipment it is desirable to provide an indicator for giving warning to the pilot that an icing condition exists, or for bringing the de-icing equipment into action automatically. The object of the invention is to enable this requirement to be met in a simple and reliable manner. Referring to the drawing, there is provided a body *A* with a longitudinal bore open



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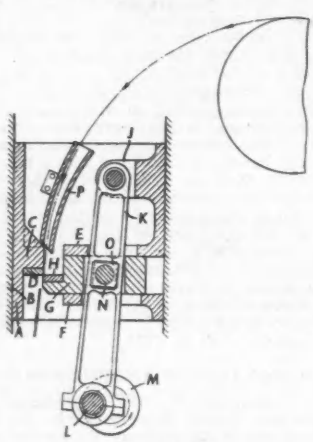
at both ends and preferably of venturi form. The body can be mounted on an aircraft in any suitable position where a stream of air can flow through it continually in the direction indicated by the arrows. Within each end of the body is mounted any convenient form of electromagnetic vibrator, consisting

of a wound magnetic core and a movable armature in the form of an iron disc. The vibrator *B*, situated adjacent to the air inlet of the body, is actuated by alternating current at, for example, audible frequency, the power required being small, for example, 1W. The similar vibrator *C*, situated adjacent to the air outlet end of the body, by vibration of its armature generates an electric current which can be utilised to actuate a warning device, or an electrical relay adapted to control the de-icing apparatus. Stems *D* and *E* extending from the armatures of the vibrators are arranged coaxially with a space between them, in which is arranged the coupling piece *F*, which interconnects the two stems, so that the armature of the vibrator *C* can be actuated by the armature of the vibrator *B*. The coupling piece may be made from any convenient limp material, preferably a short length of flat tape made from woven glass or other fibres having a low capacity for absorbing moisture. It may, however, be made from any limp material which can be rendered sufficiently rigid by the formation of ice on it. At all temperatures above freezing point, the coupling piece is unable to transmit movement from the one armature to the other. But when the moisture laden air flowing through the body is at freezing point, ice is formed on the link and renders it sufficiently rigid to transmit movement, so bringing the current-generating vibrator *C* into action. If desired, there may also be combined with the apparatus an electric heating coil for de-icing the coupling. Preferably the heater is under the control of a relay responsive to the current generated in the vibrator *C*.—*June* 23, 1954.

TOOLS AND WORKSHOP APPLIANCES

710,508. July 25, 1951.—METAL SCRAP CHOPPING MACHINES, The Wellman Smith Owen Engineering Corporation, Ltd., Parnell House, 25, Wilton Road, London, S.W.1. (*Inventor: Thomas William John Horton.*)

The invention relates to metal scrap chopping machines and more particularly to machines for chopping into short lengths scrap received from the continuous edge trimming of metal strip produced by a continuous strip rolling mill. As will be seen in the drawing, a sliding housing *A* is mounted to slide in a fixed housing *B*. An inwardly projecting abut-



No. 710,508

ment *C* on the sliding housing has a knife *D* fixed to it. The sliding housing is also provided with transverse ways *E*, *F* to permit the transverse sliding of a carrier *G* for a moving knife *H* which co-operates with the knife *D*. The sliding housing also has a pair of inwardly projecting arms *J*, between which one end of a connecting-rod *K* is pivoted. The outer or big end of the connecting-rod is connected to a crank pin *L* on a crank *M* supported by the fixed housing *B*. Intermediate its length the connecting-rod is connected through a pin *N* and sliding trunnion *O* to the transverse sliding knife carrier *G*. Also mounted within the sliding housing is a curved guide *P* for the strip scrap. This guide has, preferably, a larger opening at the admission end than at the delivery end, which is arranged close to and directed towards the cutting edges of the two knives. In operation when the crank *M* is rotated the crank pin *L* causes the connecting-rod *K* to move so as to cause the sliding housing *A* to move in a straight line up and down vertically within the fixed housing *B* and at the same time to cause the slidable carrier *G* and the knife *H* to move towards and away from the other knife *D* fixed in the slidable housing. The movement is thus such that as the two knives are arriving at the cutting position they also move vertically downward and the speed of downward movement is arranged to be the same as the speed of the strip scrap delivered to the knives. The path of the scrap is indicated.—*June* 16, 1954.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

TAB WASHERS FOR UNIFIED HEXAGONS FOR AIRCRAFT

No. SP. 107-112 : 1954. Price 2s. 6d. These British Standards specify the materials, dimensions and finish of mild steel and corrosion-resisting steel, straight, right angle and left angle tab washers suitable for use with the aircraft series of unified hexagons. A recommended method of application when washers are fitted into drill-holes is shown in an Appendix.

TEE SLOTS

No. 2485 : 1954. Price 3s. 6d. The object of this specification is to reduce as far as possible the multiplicity of odd tee slot sizes and pitches now in use. The variety of widths used make it necessary for the manufacturers of tee bolts to make a large number of different sizes to suit the slots found in machine tables, often in small quantities. The Institution found that differences in many cases were slight and no valid technical reason could be advanced for them. Usually these divergencies were due to the whim of a particular designer.

This new standard is an attempt to control this slightly chaotic situation by specifying the dimensions and tolerances of a range of tee slots and tee bolt heads from $\frac{1}{4}$in to 1in inclusive, and comparing them with their nearest metric counterparts. During the work of preparation, due note was taken of Continental and American practice and thus this standard should have a world-wide interest. The specification for milling cutters, B.S. 122, is being amended to provide suitable tee slot cutters.

METHODS OF SAMPLING AND TESTING BOILER WATER DEPOSITS

No. 2455 : 1954. Price 6s. Following on various standards published by the British Standards Institution, for water used in steam generation, this new standard, No. 2455, has now been published. B.S. 1328, "Methods of Sampling Water Used in Steam Generation," and B.S. 1427, "Tests for Water used in Steam Generation: Group A," were drawn up to provide not only a series of standard methods for the sampling and examination of waters, but also for the reporting and recording of the results obtained in the tests. The object was to make possible a direct comparison between the findings of different workers.

B.S. 2455, which is complementary to those mentioned, has the same object, but it applies not to the waters used, but to deposits forming in various parts of the equipment concerned with the generation. The standard is divided into sections in which terms used are explained and methods are recommended for collecting and describing samples, for their chemical and physical examination and for reporting the results obtained. B.S. 2455 is confined to a description of methods suitable for the more general problems encountered, but does not cater for special cases except in so far as reference is made to the possibility of physical methods of analysis. In such special cases elements other than those determined in this standard may be of interest, e.g. zinc, nickel, chromium, and the ionic form of the copper and the iron may at times be of interest. It is also known that the quantity of sample recommended for analysis will not always be available, particularly in the case of small deposits of corrosion products in high-pressure boilers, and that in such cases semi-micro- or even micro-technique may be needed.

The methods of chemical examination have been selected so as to require the minimum of time consistent with yielding results of an accuracy adequate for the purposes required. The following determinations are included :—Oil, loss on ignition, phosphate, carbonate, sulphate, chloride, sodium, silica, copper, iron, aluminium, calcium, magnesium and water-soluble salts.

THE TREATMENT OF WATER FOR LAND BOILERS

No. 2486 : 1954. Price 6s. This Standard is a complementary volume to B.S. 1170, "Treatment of Water for Marine Boilers," published in 1947. The production of the present code for land boilers has proved to be considerably more complex due to the greater variety of boilers in use in land installations. The present document is directed to the needs of operators of steam generating plant usually operated at a pressure not exceeding 250 lb per square inch.

There are two sides to a boiler, the fire side and the water side. In the majority of boiler installations much time and care are expended on keeping the fire side free from accumulation of deposit that would tend to interfere with adequate heat transference. However, in spite of the simplicity and certainty of many forms of modern water treatment, in many of the lower pressure boilers little attempt is made to keep the water side free from deposits. Scale on the water side can be far more dangerous than deposits on the fire side, since although the latter prevents the heat from reaching the metal the former prevents the heat from being transferred from the metal to the water. This may result in overheating of the metal and consequent failure and risk of explosion.

Desirable feed to all boilers is suitably conditioned water as free as possible from all unwanted salts and gases, but such water is frequently not provided in the case of the average low-pressure land boiler, and the feed consists of whatever water is available. Such water may contain objectionable impurities, but in general there is no excuse for putting these impurities into the boiler in a harmful form. There are many relatively simple methods of water treatment, the use of which will ensure freedom from scale as well as protection of the boiler from corrosion. Care should be exercised, therefore, in making use of B.S. 2486, the advice of a technical specialist being usually desirable before deciding to adopt any particular form of water treatment. This is especially important with boilers operating at pressures above 200 lb per square inch.

The purpose of this standard is to show how impurities in the water affect boiler plant and to assist in the application of an economical method of treatment suitable to the individual supply. The document is divided into parts dealing with water supplies and their treatment, feed water and boiler water, and the care of boiler installations. Additionally, a glossary of terms used in water treatment is included as an appendix.

Launches and Trial Trips

BRITISH CORPORAL, oil tanker; built by Harland and Wolff at Belfast for the British Tanker Company, Ltd.; length overall 518ft, length between perpendiculars 490ft, breadth moulded 65ft, depth moulded 36ft, deadweight 14,000 tons; twenty-seven cargo oil compartments, two cargo pump rooms, steam deck machinery, two 125kW diesel-driven generators, one 50kW steam-driven generator; one Harland-B. and W. two-stroke, single-acting, opposed-piston diesel engine, six cylinders, 620mm diameter by 1870mm combined stroke, 115 r.p.m., two single-ended multi-tubular boilers. Trial, July 1st.

THOMAS GOULDEN, self-trimming collier; built by Hall Russell and Co., Ltd., for the North Thames Gas Board; length between perpendiculars 320ft, breadth moulded 46ft, depth moulded 22ft 4in/27ft 10in; deadweight 4600 tons on 20ft draught; four holds, steam deck machinery; "North Eastern Reheat" triple expansion steam engine, 1275 i.h.p., two oil-fired cylindrical boilers.—Launch, July 1st.

WHITBY ABBEY, cargo ship; built by Hall Russell and Co., Ltd., for Associated Humber Lines; length overall 256ft, length between perpendiculars 240ft, breadth moulded 38ft 6in, depth moulded to shelter deck 21ft 6in; twelve passengers; three holds, six 7-ton and one 15-ton derricks, electric deck machinery; Kincaid Polar diesel engine, 2100 b.h.p. at 220 r.p.m.—Trial, July 7th.

CROZON, cargo liner; built by the Ateliers et Chantiers de la Loire, Nantes for the Cie d'Orbigny; length between perpendiculars 413ft 6in, breadth moulded 56ft 1$\frac{1}{2}$in, depth 34ft, draught loaded 23ft, deadweight 7700 tons, service speed 13·5 knots; six holds, eleven 5-ton and one 15-ton derricks, two complete decks, electrical deck machinery, one 150kW turbo-generator, three 100kW diesel-driven generators; one set of Parsons geared turbines, 3500 s.h.p., steam supplied at 526 lb per square inch and 752 deg. Fah. by two Penhoët boilers. Trial, July.

Catalogues

AGRON, Ltd., 14/18, Queen Victoria Street, London, E.C.4.—Leaflet describing the uses of "Ali-Solder."

THE MORGAN CRUCIBLE COMPANY, Ltd., Battersea Church Road, London, S.W.11.—Leaflets illustrating Morgan refractory bricks.

BURTON, GRIFFITHS AND CO., Ltd., Mackadown Lane, Marston Green, Birmingham, 33.—Brochure describing Deckel tyre mould profiling millers.

HACKBRIDGE AND HEWITTIC ELECTRIC COMPANY, Ltd., Walton-on-Thames, Surrey.—Leaflet No. R.249, dealing with selenium rectifier equipments.

ELLIOTT BROTHERS (LONDON), Ltd., Century Works, Lewisham, London, S.E.13.—Leaflet giving details of the "400 series" high-speed digital computer.

ABINGDON KING DICK, Ltd., Abingdon Works, Kings Road, Tyseley, Birmingham, 11.—Leaflets describing King Dick heavy duty ratchets and ultra-slim double open-ended spanners.

LONDEX, Ltd., Anerley Works, 207, Anerley Road, London S.E.20.—List 94/F, "Lectralevel" liquid level control system without float. List 159, heavy-duty mercury switch relay contactor. List 160, control units for small generating sets. List 161, portable obstruction light.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB

Fri. to Mon., Sept. 24th to 27th.—Church House, Westminster, London, S.W.1, 29th Annual Conference.